PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2004-048643
(43)Date of publication of application : 12.02.2004

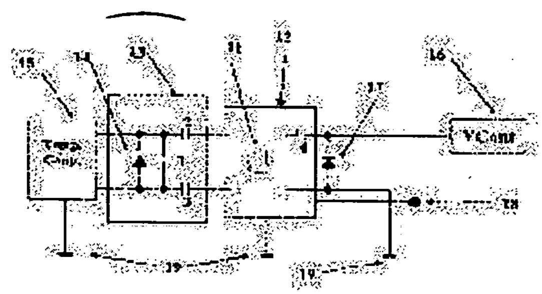
(51)Int.CI. H03B 5/32
H03B 5/04

(21)Application number : 2002-357281
(22)Date of filing : 09.12.2002

(71)Applicant : TOYO COMMUN EQUIP CO LTD
(72)Inventor : SATO TOMIO

(54) TEMPERATURE COMPENSATION PIEZOELECTRIC OSCILLATOR

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a temperature compensation piezoelectric oscillator by which an unconventionally large variable range can be obtained and high temperature stability can be obtained by an oscillator having two or more load capacity variable functions by controlling a vibrator current.



SOLUTION: This temperature compensation system is constituted by providing a quartz resonator 11 having a piezoelectric element excited by prescribed frequency, an oscillation circuit 12 having an amplifier for oscillation which is not illustrated, which excites the piezoelectric element by supplying a current to the piezoelectric element, a vibrator current control circuit 13 which controls the current of the quartz resonator 11, a compensation voltage generation circuit 15 which compensates temperature characteristics of the piezoelectric vibrator 11 and a variable capacity diode 17 for external variable which varies oscillation frequency of the oscillation circuit 12 from the external variable 16. In addition, the vibrator current control circuit 13 is constituted of a variable capacity diode 14 for vibrator current control and capacitors 1 to 3.

LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

BEST AVAILABLE COPY

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

Copyright (C); 1998,2003 Japan Patent Office

(19)日本国特許庁(JP)　(12)公開特許公報(A)　(11)特許出願公開番号
特開2004-48643
(P2004-48643A)
(43)公開日 平成16年2月12日(2004.2.12)

(51)Int.Cl.⁷	F I			テーマコード(参考)
H03B 5/32	H03B	5/32	A	5J079
H03B 5/04	H03B	5/32	E	5J081
	H03B	5/04	F	

審査請求 未請求 請求項の数 5 OL 公開請求 (全14頁)

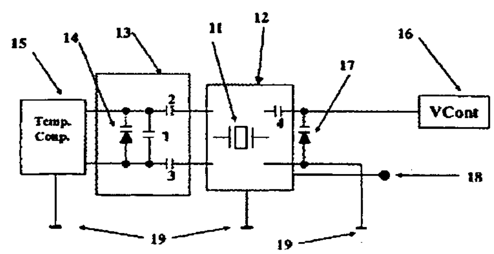
(21)出願番号 特願2002-357281(P2002-357281)
(22)出願日 平成14年12月9日(2002.12.9)

(71)出願人 000003104
東洋通信機株式会社
神奈川県川崎市幸区塚越三丁目484番地
(74)代理人 100085660
弁理士 鈴木 均
(72)発明者 佐藤 富雄
神奈川県高座郡寒川町小谷二丁目1番1号
東洋通信機株式会社内

Fターム(参考) 5J079 AA04 BA02 CB01 DA13 FA02
FA13 FA14 FA21 FA22 FA24
FB02 GA02
5J081 AA03 CC07 CC17 DD03 DD21
DD26 EE05 FF08 FF11 GG04
HH06 KK02 KK09 KK22 LL05
MM01

(54)【発明の名称】温度補償型圧電発振器

(57)【要約】
【課題】振動子電流を制御することにより、２つ以上の負荷容量可変機能を備える発振器では従来にない大きな可変範囲を得ることができると共に、高い温度安定度を得ることができる温度補償型圧電発振器を提供する。
【解決手段】この温度補償方式は、所定の周波数で励振される圧電素子を備えた水晶振動子１１、及び圧電素子に電流を流して圧電素子を励振させる図示しない発振用増幅器、を有する発振回路１２と、水晶振動子１１の電流を制御する振動子電流制御回路１３と、前記圧電振動子１１の温度特性を補償する温度補償電圧発生回路１５と、発振回路１２の発振周波数を外部可変１６から可変する外部可変用可変容量ダイオード１７と、を備えて構成される。尚、振動子電流制御回路１３は、振動子電流制御用可変容量ダイオード１４と、コンデンサ１～３により構成される。
【選択図】　図１



【特許請求の範囲】
【請求項１】
所定の周波数で励振される圧電素子を備えた圧電振動子、及び前記圧電素子に電流を流して前記圧電素子を励振させる発振用増幅器、を有する発振回路と、前記圧電振動子の電流を制御する振動子電流制御部と、前記圧電振動子の温度特性を補償する温度補償回路と、外部電圧により前記発振回路の負荷容量を可変して発振周波数を可変する可変容量ダイオードと、を備え、
前記温度補償回路は、前記圧電振動子の温度特性を補償する関数電圧を発生し、該関数電圧を前記振動子電流制御部に入力することにより、前記振動子電流を制御して前記発振回路の発振周波数を可変して前記圧電振動子の温度特性を補償し、前記外部電圧により前記可変容量ダイオードの印加電圧を可変することにより、前記発振回路の発振周波数を可変することを特徴とする温度補償型圧電発振器。
【請求項２】
所定の周波数で励振される圧電素子を備えた圧電振動子、及び前記圧電素子に電流を流して前記圧電素子を励振させる発振用増幅器、を有する発振回路と、前記圧電振動子の電流を制御する振動子電流制御部と、前記圧電振動子の温度特性を補償する温度補償回路と、外部電圧により前記発振回路の負荷容量を可変して発振周波数を可変する可変容量ダイオードと、を備え、
前記温度補償回路は、前記圧電振動子の温度特性を補償する関数電圧を発生し、該関数電圧を前記可変容量ダイオードに印加して前記発振回路の負荷容量を可変することにより、前記発振回路の発振周波数を可変して前記圧電振動子の温度特性を補償し、前記外部電圧により前記振動子電流制御部に入力する電圧を可変することにより、前記発振回路の発振周波数を可変することを特徴とする温度補償型圧電発振器。
【請求項３】
前記発振回路の負荷に、負荷容量を可変することにより前記発振回路の発振周波数を可変するリアクタンス素子を更に挿入することを特徴とする請求項１又は２に記載の温度補償型圧電発振器。
【請求項４】
前記発振回路の負荷に、負荷容量を可変することにより前記発振回路の発振周波数を可変する可変リアクタンス素子を更に挿入し、当該発振器外部より前記可変リアクタンス素子の容量を可変することにより前記発振回路の発振周波数を制御可能とすることを特徴とする請求項１又は２に記載の温度補償型圧電発振器。
【請求項５】
負荷容量を可変することにより発生する補償歪みを補正する補正用可変容量ダイオードを更に備え、
前記補正用可変容量ダイオードは、前記温度補償回路により発生する関数電圧により前記振動子電流制御部の負荷容量を可変することにより発生する補償歪みを補正するように働くとすることを特徴とする請求項１に記載の温度補償型圧電発振器。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】
本発明は、温度補償型圧電発振器に関し、さらに詳しくは、陸上移動体通信分野及び衛星通信分野の基準周波数として使用される圧電発振器の温度補償方法に関するものである。
【０００２】
【従来の技術】
近年、携帯電話に代表される陸上移動帯通信は利用範囲が拡大の一途を辿っている。それに伴い、携帯電話の普及もすさまじく技術開発競争が激化しており、携帯電話に使用される水晶発振器も小型化・ローコスト化、更に高性能化が要求されている。水晶振動子は図２３に示す様に、周囲温度の変化に対し発振周波数が３次曲線的に変化する。このため高い安定度を得るために発振回路には振動子の温度特性を相殺するための温度補償回路を設

けており、そして温度補償方式には直接温度補償方式、間接温度補償方式があるが、いずれの方式においても発振回路の負荷容量を可変し温度補償を行うのが一般的である。また現在の発振器はＰＬＬ回路（位相同期回路）等と接続して使用するため、外部より電圧を印加し周波数を可変する機能（Ｖｃｏｎｔ）の付加が必須である。即ち、発振回路内に負荷容量を可変し周波数を変化させるための可変機能を２つ以上設けることになる。これらの機能は必然的に可変範囲に干渉を起こすことになる。例えば、温度補償量として付加容量の変化により１００ｐｐｍを必要としている場合、そこに２０ｐｐｍの外部可変を行うと全体の付加容量に対する温度補償回路の付加容量の比率が代わるので、付加容量の変化に対する周波数変化量が変化し、９９ｐｐｍの温度補償量となる場合があり、温度特性を１ｐｐｍ悪化させることになってしまう。

【０００３】

図２４に従来の外部可変機能付温度補償型水晶発振器のブロック図を示す。

温度補償電圧発生部１１６は補償関数電圧を発生し、可変容量ダイオード１１４に印加する。同ダイオードの容量変化に基づき発振回路の負荷容量が変化し、これにより水晶振動子１１１の発振周波数の温度特性がフラットになるように制御されるので、発振器の周波数温度特性を優れたものにする。この場合、外部可変（Ｖｃｏｎｔ）１１７より電圧を入力して可変容量ダイオード１１５へ印加することにより周波数を可変する。このことにより発振周波数が変化するだけでなく、温度補償量にも影響を与える。

温度補償量と外部可変量には振動子の容量比（$\gamma = C_o / C_1$）に強い関係があることを下記に示す。

１．基礎理論

式（１）に水晶発振器の発振時の直列共振周波数からのオフセット周波数偏差を示す。

$$D_L = \frac{1}{2} \times \frac{C_1}{(C_0 + C_L)} \quad \text{(1)}$$

D_L：発振周波数偏差

C_1：振動子の直列容量

C_0：振動子の並列容量

C_c：回路の容量

図２５に式（１）が示す発振周波数等価ブロック図を示す。

式（２）に示すようにC_LをC_xとC_yとC_cの３つの直列用量に分離したものが図２６である。

$$\frac{1}{C_L} = \frac{1}{C_x} + \frac{1}{C_y} + \frac{1}{C_c} \quad \text{(2)}$$

例えばC_xは温度補償容量、C_yは周波数調整又は外部可変容量、C_cは発振回路容量とすることができる。ここで、$C_o = 0$（Ｏｐｅｎ）とすると、（３）式の変換が可能となる。

$$D_L = \frac{C_1}{2C_L} = \frac{C_1}{2}\left(\frac{1}{C_x} + \frac{1}{C_y} + \frac{1}{C_c}\right) = \frac{C_1}{2C_x} + \frac{C_1}{2C_y} + \frac{C_1}{2C_c} \quad \text{(3)}$$

則ち、C_x、C_y、C_cそれぞれの容量に対して直列共振周波数からのシフト量がそれぞれ加算されるため、それぞれの容量変化に対し、周波数偏差が抑圧等の干渉を受けることがない。

しかしながら、水晶振動子等の圧電素子は振動を促すための電極を必要とするため必ず電極間容量：Ｃｏを省くことはできない。
（１）式及び（２）より（４）式を得る。

$$D_L = \frac{C_1}{2(C_0 + C_L)} = \frac{C_1}{2C_0\left(1 + \frac{C_L}{C_0}\right)} = \frac{1}{2\gamma\left(1 + \frac{1}{\frac{C_0}{C_L}}\right)} = \frac{1}{2\gamma\left(1 + \frac{1}{\frac{1}{x} + \frac{1}{y} + \frac{1}{c}}\right)} = \frac{1}{2\gamma} \times \frac{x + y + \frac{xy}{c}}{x + y + xy + \frac{xy}{c}} \cdots\cdots (4)$$

$$D_L = \frac{1}{2\gamma} F(x,y,c), \cdots\cdots DS_x = \frac{1}{2\gamma}\frac{dF}{dx}$$

$$F(x,y,c) = \frac{x + y + \frac{xy}{c}}{x + y + xy + \frac{xy}{c}}, \cdots\cdots S_x = \frac{dF}{dx} = \frac{-c^2y^2}{\{xy + c(x + y + xy)\}^2} \cdots\cdots (5)$$

$$\gamma = \frac{C_0}{C_1}, \ldots x = \frac{C_x}{C_0}, y = \frac{C_y}{C_0}, c = \frac{C_c}{C_0} \cdots\cdots (6)$$

$F(x,y,c)$：正規化関数、$\frac{1}{2\gamma} = 1$とする、即ち、最大化変幅＝１とする周波数偏差を示す。

S_x：$F(x,y,c)$を偏微分した値、ｘの感度（単位変化あたりの周波数偏差）を示す。

γ：容量比、x：正規化可変容量1, y：正規化可変容量2、ｃ：発振回路容量

【０００４】
図２７にｃ＝２５、ｙ＝２０、３０、８０とし、ｘを可変、Ｆ（ｘ、ｙ、ｃ）のシミュレーション図を示す。また図２８に同図の拡大図を示す。この図から、ｘが小さい領域で感度が大きく正規化周波数偏差の変化量が大きいことが分る。
図２９はγ＝２００、即ち最大化偏幅１／２γ＝２５００ｐｐｍとした場合の周波数偏差ＤＬ（ｘ、ｙ、ｃ）とＳｘを示す図である。図３０はｘ＝１０とした場合のＤＬを基準とする周波数偏差を示す図である。図３１はｙ＝３０でｘ＝１０とした場合のＤＬ曲線からのずれ、即ちｙ＝３０でｘ＝１０、ｙ＝８０でｘ＝１０の各曲線のｘの値に対するＤＬの差を示す図である。即ちこれはｘの値に対する基準曲線からのずれであり、即ち干渉量となる。この図から明らかなように、ｘの値が小さい程各曲線の偏差が大きくなることを示している。
図３２の縦軸は図３１の基準曲線からのずれの偏差を示し、横軸は図３０のｘ＝１０を基準とし、ｙ＝３０とした場合の周波数偏差、即ちＤＬの値を示す。図３２の場合、ｘ（可変容量１）にて－４０ｐｐｍ周波数を下げ、それからｙ（可変容量２）にて３０ｐｐｍ周波数を上げると、約１ｐｐｍ程歪む、－１００ｐｐｍ周波数を下げると、２．８ｐｐｍほど歪むことになる。
このことは、２つの可変を含む発振器、即ちＯＣＸＯ（高安定発振器）への温度補償機能付加、またＶＣＸＯ（電圧制御発振器）への温度補償機能付加、ＴＣＸＯ（温度補償発振器）へのＶｏｌｔａｇｅ　Ｃｏｎｔ（電圧制御機能）付加等について考慮すべき事項であることがわかる。
【０００５】
【発明が解決しようとする課題】
前記図２４のように周波数の外部制御機能と温度補償機能等の負荷容量を可変するために、２つ以上の負荷容量可変機能を備える発振器には相互の可変が可変量あるいは補償量に歪みを与えるという大きな課題がある。
また、水晶振動子の発振周波数は大きく負荷容量、周囲温度、及び振動子電流の３つの要素で可変できる。この中で、負荷容量可変による周波数の可変は最も多く使用されている

。また高安定発振器では振動子、及び周辺回路の温度を一定にすることにより高い安定度を得ている。しかし振動子電流を使用して可変するという例はほとんど無く、一部の高安定発振器にて経年変化改善のため振動子電流を抑圧する回路を設けているに過ぎない。
そこで、本発明では振動子電流による周波数制御が負荷容量の可変量にほとんど影響を与えないことを利用して、振動子電流を制御することにより、水晶振動子の周波数温度特性を補償しようとするものである。
本発明は、かかる課題に鑑み、振動子電流を制御することにより、２つ以上の負荷容量可変機能を備える発振器では従来にない大きな可変範囲を得ることができると共に、高い温度安定度を得ることができる温度補償型圧電発振器を提供することを目的とする。
【０００６】
【課題を解決するための手段】
本発明はかかる課題を解決するために、請求項１は、所定の周波数で励振される圧電素子を備えた圧電振動子、及び前記圧電素子に電流を流して前記圧電素子を励振させる発振用増幅器、を有する発振回路と、前記圧電振動子の電流を制御する振動子電流制御部と、前記圧電振動子の温度特性を補償する温度補償回路と、外部電圧により前記発振回路の負荷容量を可変して発振周波数を可変する可変容量ダイオードと、を備え、前記温度補償回路は、前記圧電振動子の温度特性を補償する関数電圧を発生し、該関数電圧を前記振動子電流制御部に入力することにより、前記振動子電流を制御して前記発振回路の発振周波数を可変して前記圧電振動子の温度特性を補償し、前記外部電圧により前記可変容量ダイオードの印加電圧を可変することにより、前記発振回路の発振周波数を可変することを特徴とする。
従来の発振器は、ＰＬＬ回路（位相同期回路）等と接続して使用するため、発振回路内に負荷容量を可変し周波数を変化させるための可変機能を２つ以上設けることになる。これらの機能は必然的に可変範囲に干渉を起こすことになる。そこで本発明では、温度補償回路により関数電圧を発生して振動子電流を制御することにより、発振回路の発振周波数を可変として圧電振動子の温度特性を補償し、周波数の可変は発振器の負荷容量を、外部電圧を印加することにより容量が可変となる可変容量ダイオードを使用するものである。
かかる発明によれば、振動子電流を制御することにより、温度特性を補償するので、２つ以上の負荷容量可変機能を備える発振器において大きな可変範囲を得ることができると共に、相互の可変範囲に干渉を与えることなく高い温度安定度を得ることができる。
請求項２は、所定の周波数で励振される圧電素子を備えた圧電振動子、及び前記圧電素子に電流を流して前記圧電素子を励振させる発振用増幅器、を有する発振回路と、前記圧電振動子の電流を制御する振動子電流制御部と、前記圧電振動子の温度特性を補償する温度補償回路と、外部電圧により前記発振回路の負荷容量を可変して発振周波数を可変する可変容量ダイオードと、を備え、前記温度補償回路は、前記圧電振動子の温度特性を補償する関数電圧を発生し、該関数電圧を前記可変容量ダイオードに印加して前記発振回路の負荷容量を可変することにより、前記発振回路の発振周波数を可変して前記圧電振動子の温度特性を補償し、前記外部電圧により前記振動子電流制御部に入力する電圧を可変することにより、前記発振回路の発振周波数を可変することを特徴とする。
請求項１では、温度特性を補償する温度補償回路を振動子電流制御部に接続して温度補償を行うが、本発明では、温度補償回路で発生した関数電圧を可変容量ダイオードに印加することにより、発振周波数を可変して温度補償を行うものである。また、周波数の可変は外部電圧を振動子電流制御部に印加することにより行うものである。
かかる発明によれば、請求項１と同様の作用効果を奏する。
【０００７】
請求項３は、前記発振回路の負荷に、負荷容量を可変することにより前記発振回路の発振周波数を可変するリアクタンス素子を更に挿入することを特徴とする。
発振回路の負荷容量を可変することにより、温度補償電圧を印加したときの周波数偏差の勾配が変化する。言い換えると、負荷容量を可変することにより発振周波数を変えることができる。

かかる発明によれば、発振周波数を可変するリアクタンス素子を更に挿入したので、発振周波数を簡単な回路構成で変更することができる。
請求項４は、前記発振回路の負荷に、負荷容量を可変することにより前記発振回路の発振周波数を可変する可変リアクタンス素子を更に挿入し、当該発振器外部より前記可変リアクタンス素子の容量を可変することにより前記発振回路の発振周波数を制御可能とすることを特徴とする。
リアクタンス素子を可変トリマのように任意にその容量が可変できれば、外部からそのトリマを可変して発振周波数を制御できる。
かかる発明によれば、リアクタンス素子を可変トリマのように任意に可変できる可変リアクタンス素子を使用するので、外部から容易に発振周波数を制御することができる。
請求項５は、負荷容量を可変することにより発生する補償歪みを補正する補正用可変容量ダイオードを更に備え、前記補正用可変容量ダイオードは、前記温度補償回路により発生する関数電圧により前記振動子電流制御部の負荷容量を可変することにより発生する補償歪みを補正するように働くとすることを特徴とする。
かかる発明によれば、補正用可変容量ダイオードを振動子電流制御部に備えるので、負荷容量を可変することにより発生する補償歪みを補正して、印加電圧に対する周波数偏差を更に低減することができる。
【０００８】
【発明の実施の形態】
以下、本発明を図に示した実施形態を用いて詳細に説明する。但し、この実施形態に記載される構成要素、種類、組み合わせ、形状、その相対配置などは特定的な記載がない限り、この発明の範囲をそれのみに限定する主旨ではなく単なる説明例に過ぎない。
一般に水晶振動子は水晶の応力・歪みとの関係が非直線であるため、その振動子電流によって共振周波数が下記のように変化することが確かめられている。

$$\cdots\cdots\cdots\cdots\cdots\frac{\Delta f}{f}=Ki^2$$

……………i:振動子電流

……………K:カット・振動モード・電極寸法・・・等で決まる固有定数

この発振時の振動子電流を制御する方法として、一部の高安定水晶発振器（ＯＣＸＯ）でＡＧＣ回路を経年変化改善のために挿入しているが、回路的に複雑であり実用的ではない。
ここでは、同一出願人による特願２００２－２６５０００公報に記載されている回路を用いることで、振動子電流が制御可能であることを利用して温度補償シミュレーションを行う。
【０００９】
図１は、本発明の温度補償方式のブロック図である。この温度補償方式は、所定の周波数で励振される圧電素子を備えた水晶振動子１１、及び圧電素子に電流を流して圧電素子を励振させる図示しない発振用増幅器、を有する発振回路１２と、水晶振動子１１の電流を制御する振動子電流制御回路１３と、前記圧電振動子１１の温度特性を補償する温度補償電圧発生回路１５と、発振回路１２の発振周波数を外部可変電圧１６にて可変される外部可変用可変容量ダイオード１７と、を備えて構成される。尚、振動子電流制御回路１３は、振動子電流制御用可変容量ダイオード１４と、コンデンサ１～３により構成される。
このブロック図の概略動作は、温度補償電圧発生回路１５が、水晶振動子１１の温度特性を補償する関数電圧を発生し、この関数電圧を振動子電流制御回路１３に印加することにより、この振動子電流制御回路１３は水晶振動子１１の振動子電流を制御して発振回路１２の発振周波数を可変とすることにより、水晶振動子１１の温度特性を補償するものである。
図２は実施回路例を示す図である。同じ構成要素には同じ参照番号が付されているので、重複する説明は省略する。ここでは、各定数を以下のように設定した。

Ｒ１＝３９０Ω、Ｒ２＝１ｋΩ、Ｒ３／Ｒ４＝１０ｋΩ、Ｒ５＝２０ｋΩ、Ｒ６／Ｒ７＝１００ｋΩ、C_o＝可変、Ｃ１／Ｃ２＝２７ｐＦ、Ｃ３＝１００ｐＦ、Ｃ４＝１０ｐＦ、Ｃ５／Ｃ６＝１００００ｐＦ、Ｃ７＝０ｐＦ、Ｃ８／Ｃ９＝０．１μＦ、ＴＲ１／ＴＲ２＝２ＳＣ３７３２、Ｄ１＝ＭＡ２Ｓ３０４、Ｘｔａｌ＝２６ＭＨｚ・Ａｔ－Ｃｕｔ１ｓｔ、ＶＣＣ＝５Ｖｄｃ、ＶＤ＝直流電源、Ｖ．Ｖ＝高周波電圧計、Ｆｒｅｑ．Ｃ．＝周波数カウンター

発振回路はカスコード接続のコルピッツ発振回路であり、トランジスタＴＲ１のコレクタとトランジスタＴＲ２のエミッタ間に、挿入接続した振動子電流制御回路１３に発振出力を供給する。また、振動子電流制御回路１３には抵抗Ｒ６、Ｒ７を介して温度補償電圧発生回路１５を接続して、関数電圧を供給する。

【００１０】

図３は本発明の温度補償電圧発生回路１５の回路図と振動子電流制御回路１３の回路図である。同じ構成要素には同じ参照番号が付されているので、重複する説明は省略する。また下記に温度補償電圧発生回路１５のシミュレーション時の定数を示す。

Ｒ１・３・４＝１０ｋΩ、Ｒ２＝６．５Ω、Ｒ５＝可変調整、Ｄ１＝１Ｓ９５３、ＩＣ１＝ＴＣ７５Ｓ５１ＦＵ

Ｒ１０＝１０ｋΩ、Ｒ１１＝３０ｋΩ、ＩＣ２＝ ＴＣ７５Ｓ５１ＦＵ

Ｒ１２＝１０ｋΩ、Ｒ１３＝１４０ｋΩ、ＩＣ３＝ ＴＣ７５Ｓ５１ＦＵ

Ｒ１４＝１０ｋΩ、Ｒ１５＝１４０ｋΩ、ＩＣ４＝ ＴＣ７５Ｓ５１ＦＵ

Ｒ６＝９．６ｋΩ、Ｒ７＝１１．１ｋΩ、 Ｒ８＝１１．３ｋΩ、Ｒ９＝８ｋΩ、

Ｒ１６・１７・１８・２１・２２＝１００ｋΩ、Ｒ１９・２０＝２００ｋΩ、Ｄ２＝ＭＡ２Ｓ３０４、Ｃ３・４・５＝０．１μＦ

Ｘｔａｌ＝１３ＭＨｚ、γ＝２４０、C_o＝１．３５ｐＦ、Ｃｐ＝４０ｐＦ、Ｃｓ＝３５ｐＦ

Ｖｃｃ＝３．０Ｖ、

【００１１】

図４はC_o＝２０ｐＦとし、ＶＤの電圧を可変することにより、可変容量ダイオードＤ１への印加電圧を可変する。縦軸はＶＤ＝１Ｖとしたときの周波数を基準とする偏差を示し、横軸はＶＤ、可変容量ダイオードＤ１への印加電圧を示す。

同様に図５はC_o＝１２ｐＦ、図６はC_o＝４３ｐＦとした場合の結果を示す。各図よりＤ１への印加電圧に対し発振周波数及び振動子電流も同様な変化をしていることがわかる。

振動子電流は（７）式で求める。

$$I_X(\text{Xtal Current}) = \omega CV \cdots\cdots (7)$$

$$V: C_3\text{の両端電圧：VV 単位rms}$$

$$C: C_3\text{の容量 :100pF}$$

$$\omega = 2\pi f \qquad f = 26\text{MHz}$$

図７はＶＤの変化に対する各C_oをパラメーターとする振動子電流の変化を示す。この図から振動子電流の変化はほとんどC_oの値によらないことが解る。

図８はＶＤの変化に対する各C_oをパラメーターとする周波数偏差を示す。この図から明らかに、C_oの値により僅かであるが変化量が異なることが解る。

図９は、可変容量ダイオードＤ１：ＭＡ２Ｓ３０４の印加電圧対容量変化特性を示すものであり、実測データ及びその近似関数を示す図である。この図から近似関数に良く一致していることが解る。

図１０は、可変容量ダイオードＤ１の容量変化に対する振動子電流を示す図である。この図から、容量C_oの変化に殆ど影響されないことが解る。

図１１は、可変容量ダイオードＤ１の容量変化に対する周波数偏差を示す。但しＶＤ＝１

Ｖｄｃ、ＣＶ＝２６ｐＦを基準とする。また各C_oをパラメータとした近似関数を示す。図１２は容量：C_oを可変した場合の発振周波数変化を示す図である。但しC_o＝２０ｐＦを基準とする。またＤ１容量は、ＶＤ＝１Ｖｄｃ、即ちＣＶ＝２６ｐＦとする。この結果よりC_o＝１２ｐＦ～C_o＝４３ｐＦまで可変すると周波数偏差として約２８０ｐｐｍの変化を得る。

【００１２】

図１３は本回路定数でのシミュレーション結果を示す図である。図の各記号は図３の各記号の電圧変化を示す。

［ａ］は演算増幅器ＩＣ１の出力で温度変化に対し単調減少を示す。

［ｂ］は演算増幅器ＩＣ２の出力で振動子の変曲点近傍の変化を補償する、０℃近くより５０℃近くまで単調増加を示す。

［ｃ］は演算増幅器ＩＣ３の出力で振動子の低温度側を補償する、－３０℃近くから－１０℃近くまで単調増加を示す。

［ｄ］は演算増幅器ＩＣ４の出力で振動子の高温度側を補償する、６５℃近くから９０℃近くまで単調増加を示す。

図１４に同じく、図３の温度補償電圧発生回路１５の各部の電圧変化を示す。［ｅ］は［ｂ］とＶｃｃを合成した電圧変化を示す。［ｆ］は［ｃ］と［ｄ］を合成した電圧変化を示す。［ＶＤ］は可変容量ダイオードのカソード・アノード間の電圧変化を示す。

【００１３】

図１５は、図１１に基づき、振動子電流制御用可変容量ダイオード：Ｄ１の変化による発振周波数偏差に従い、温度補償をシミュレーションした結果である。

即ち、温度補償電圧発生回路１５からの補償電圧を振動子電流制御用可変容量ダイオード：Ｄ１で受け振動子電流制御回路１３の容量変化とする。図１１より、C_oをパラメータとする容量変化対周波数偏差の関係式より、振動子の温度特性を適切に補償する並列容量Ｃ７及びＣ８・Ｃ９を設定する。本シミュレーションでは、１．C_o＝２０ｐＦに設定、Ｃ７＝５ｐＦ、Ｃ８／Ｃ９＝６６ｐＦに設定することにより温度補償シミュレーションを行う。その結果、－３０℃～＋８５℃で温度補償特性±２ｐｐｍ以下を得る。

２．上記設定のまま、「即ち、Ｃ７＝５ｐＦ、Ｃ８／Ｃ９＝６６ｐＦに設定したまま、」C_o＝１２ｐＦ、及びC_o＝４３ｐＦに変更する。その結果C_o＝１２ｐＦでは０℃近傍で周波数約０．８ｐｐｍ上昇、５５℃近傍では周波数約０．８ｐｐｍ低下する。また、C_o＝４３ｐＦでは０℃近傍で周波数約１ｐｐｍ低下、５５℃近傍では周波数約１ｐｐｍ上昇する。

更に、図１２のC_o対周波数偏差結果よりC_o＝２０ｐＦ→C_o＝１２ｐＦの負荷容量可変により＋１５０ｐｐｍ上昇、C_o＝２０ｐＦ→C_o＝４３ｐＦに負荷容量可変により－１３０ｐｐｍ低下する。

即ち、従来の負荷容量可変だけによる温度補償と外部可変では得ることのできない結果である。

図１６は、本発明の温度補償方式の他の例のブロック図である。同じ構成要素には同じ参照番号が付されているので、重複する説明は省略する。図１６が図１と異なる点は、温度補償電圧発生回路１５と外部可変１６の位置が異なる点である。即ち、外部可変１６により振動子電流制御回路１３を制御し、温度補償電圧発生回路１５により可変容量ダイオード１７を可変して温度補償している。

以上のように、本発明は水晶振動子の温度特性を補償するための周波数変化を振動子電流を制御することにより行い、外部制御により周波数を可変する必要がある場合は従来通り負荷容量可変とする。

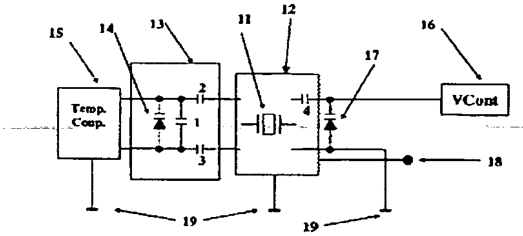
このようにすることにより、それぞれの干渉がなくなるため、特に外部可変による周波数変化を大きくすることができる。また外部可変による温度補償量への干渉が少ないため優れた温度特性を得ることもできる。このことは、これからの水晶発振器あるいは圧電発振器の機能拡大に大きく貢献することが予測される。

【００１４】

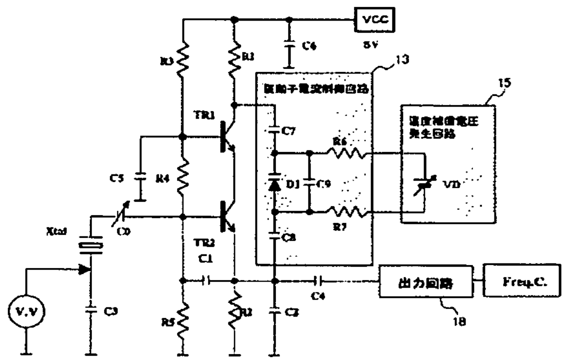
図１７は図８に示す結果、即ち負荷容量の値による振動子電流制御可変容量ダイオードＤ１への印加電圧による周波数偏差の相違（負荷容量可変による補償歪み）を補正する回路を示す図である。本発明による振動子電流制御方式の制御量はコレクタ・エミッタ間容量とエミッタ・ＧＮＤ間容量の比で決まり、コレクタ・エミッタ間容量に対しエミッタ・ＧＮＤ間容量が小さいほど制御量は大きくなる。
このことより、外部電圧Ｖｃの可変により可変リアクタンス素子（可変容量ダイオードＤ２）を制御し、負荷容量を可変することで周波数を可変すると同時に、エミッタ・ＧＮＤ間に可変リアクタンス素子（可変容量ダイオードＤ３）を挿入し、外部電圧Ｖｃにより同ダイオードの容量を可変することにより、可変容量ダイオードＤ２を制御するに伴う負荷容量可変による補償歪みを補正することができる。この場合、負荷容量を小さくし周波数を高く可変することと、エミッタ・ＧＮＤ間の容量を小さくし補償量を増加し、歪み補正を行うことが、更に負荷容量を小さくすることであり、補正歪み制御が周波数可変と同一制御でできることは大きな効果である。
図１８は振動子に直列に接続するコンデンサC_oに対し下記の対策を行い測定した結果である。
C_o＝２０ｐＦ…エミッタ・ＧＮＤ間容量：Ｃ２＝２７ｐＦを基準とし、C_o＝１２ｐＦ…エミッタ・ＧＮＤ間容量：Ｃ２＝１８ｐＦ、C_o＝４３ｐＦ…エミッタ・ＧＮＤ間容量：Ｃ２＝３０ｐＦ、として、補正歪みを行い、振動子電流制御可変容量ダイオードＤ１への印加電圧による周波数偏差を示した。
補正前図８の結果では、補正前ＶＤ＝２Ｖｄｃに対し　相違量（歪み量）＝約８ｐｐｍに対し、補正後ＶＤ＝２Ｖｄｃでは、相違量（歪み量）＝約２ｐｐｍとなり、これが歪み（Ｄ１印加電圧対周波数偏差特性における容量C_oの依存性）改善となる。
図１９は歪み補正を行った場合の振動子電流制御可変容量ダイオードＤ１への容量変化による周波数偏差の関係を示す図である。
図２０は補正歪みを行った場合の温度特性シミュレーション結果を示す図である。
図２１は図１５の温度特性シミュレーション、即ち歪み補正前の結果を示す図である。
以上の結果から明らかなように、補正前の歪み量＝約１．６ｐｐｍが補正を行うことにより、歪み補正後＝約０．４ｐｐｍに改善、約１／４になることを示している。
【００１５】
【発明の効果】
以上記載のごとく請求項１の発明によれば、振動子電流を制御することにより、温度特性を補償するので、２つ以上の負荷容量可変機能を備える発振器において大きな可変範囲を得ることができると共に、相互の可変範囲に干渉を与えることなく高い温度安定度を得ることができる。
また請求項２では、請求項１と同様の作用効果を奏する。
また請求項３では、発振周波数を可変するリアクタンス素子を更に挿入したので、発振周波数を簡単な回路構成で変更することができる。
また請求項４では、リアクタンス素子を可変トリマのように任意に可変できる可変リアクタンス素子を使用するので、外部から容易に発振周波数を制御することができる。
また請求項５では、補正用可変容量ダイオードを振動子電流制御部に備えるので、負荷容量を可変することにより発生する補償歪みを補正して、印加電圧に対する周波数偏差を更に低減することができる。
【図面の簡単な説明】
【図１】本発明の温度補償方式のブロック図である。
【図２】本発明の温度補償方式の回路実施例の図である。
【図３】本発明の温度補償方式の実施回路例（補償電圧発生回路）の図である。
【図４】本発明の実施回路例－１、Ｄ１印加電圧対周波数偏差＆振動子電流を示す図である。
【図５】本発明の実施回路例－２、Ｄ１印加電圧対周波数偏差＆振動子電流を示す図である。

【図６】本発明の実施回路例－３、Ｄ１印加電圧対周波数偏差＆振動子電流を示す図である。
【図７】本発明の実施回路例－４、Ｄ１印加電圧対振動子電流を示す図である。
【図８】本発明の実施回路例－５、Ｄ１印加電圧対周波数偏差を示す図である。
【図９】本発明の可変容量ダイオードＤ１：ＭＡ２Ｓ３０４の測定結果と近似関数を示す図である。
【図１０】本発明の実施回路例－６、Ｄ１可変容量対振動子電流を示す図である。
【図１１】本発明の実施回路例－７、Ｄ１可変容量対周波数偏差を示す図である。
【図１２】本発明の実施回路例－８、$Ｃ_o$可変容量対周波数偏差を示す図である。
【図１３】本発明の実施回路例－９、温度補償電圧発生回路シミュレーション結果－１を示す図である。
【図１４】本発明の実施回路例－１０、温度補償電圧発生回路シミュレーション結果－２を示す図である。
【図１５】本発明の実施回路例－１１振動子の温度特性と温度補償周波数偏差及び補償のシミュレーション結果を示す図である。
【図１６】本発明の温度補償方式他の例のブロック図である。
【図１７】温度補償方式の歪み補正回路実施例を示す図である。
【図１８】発明回路（歪み補正回路付き）実施例－１２Ｄ１印加電圧対周波数偏差を示す図である。
【図１９】発明回路（歪み補正回路付き）実施例－１３Ｄ１可変容量対周波数偏差を示す図である。
【図２０】発明回路（歪み補正回路付き）実施例－１４温度補償のシミュレーション結果を示す図である。
【図２１】発明回路実施例－１５温度補償のシミュレーション結果を示す図である。
【図２２】発明温度補償方式（歪み補正回路付き）のブロック図である。
【図２３】Ａｔ－Ｃｕｔ振動子の切断角度の相違による温度特性シミュレーションを示す図である。
【図２４】従来温度補償方式のブロック図である。
【図２５】共振周波数等価ブロック図－１である。
【図２６】共振周波数等価ブロック図－２である。
【図２７】Ｆ（ｘ、ｙ、ｃ）＆Ｓｘシミュレーション図である。
【図２８】Ｆ（ｘ、ｙ、ｃ）＆Ｓｘシミュレーション拡大図である。
【図２９】Ｄ（ｘ、ｙ、ｃ）＆Ｓｘシミュレーション図である。
【図３０】Ｄ（ｘ、ｙ、ｃ）＆Ｓｘシミュレーション図である。
【図３１】ΔＦ（ｘ、ｙ、ｃ）シミュレーション図である。
【図３２】ΔＦ（ｘ、ｙ、ｃ）＆Ｆシミュレーション図である。
【符号の説明】
１１　水晶振動子、１２　発振回路、１３　振動子電流制御回路、１４　振動子電流制御用可変容量ダイオード、１５　温度補償電圧発生回路、１６　外部可変、１７　外部可変用可変容量ダイオード、１８　出力回路、１９　ＧＮＤ

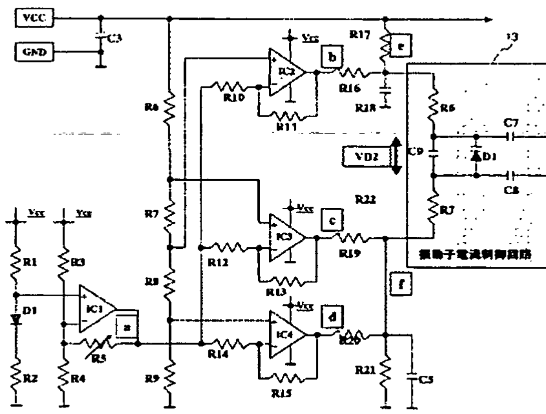
【図１】



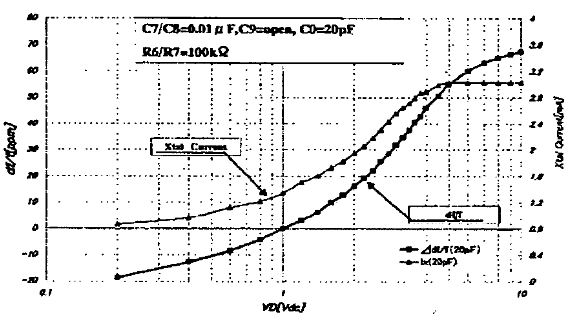
【図２】



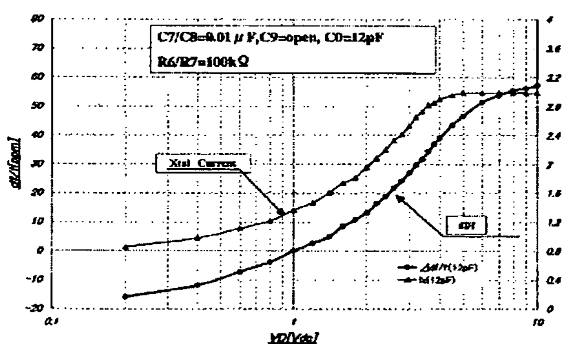
【図３】



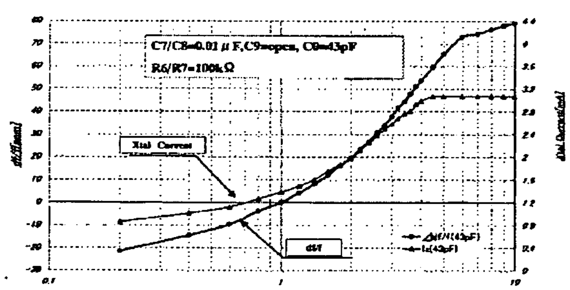
【図４】



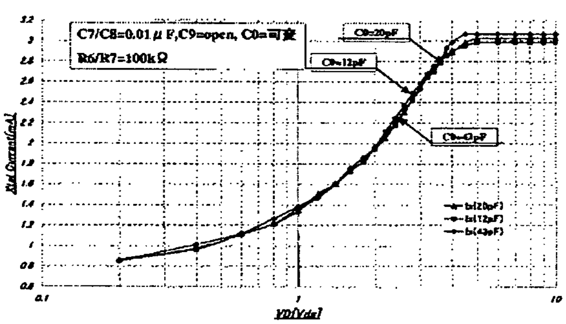
【図５】



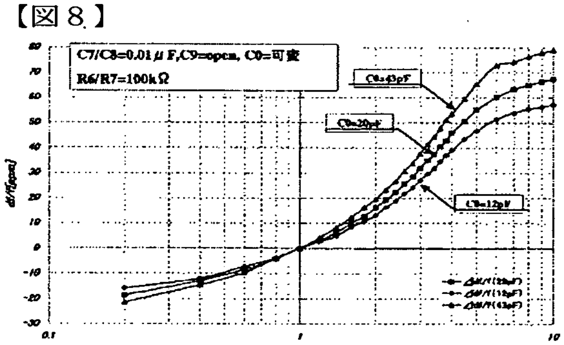
【図６】



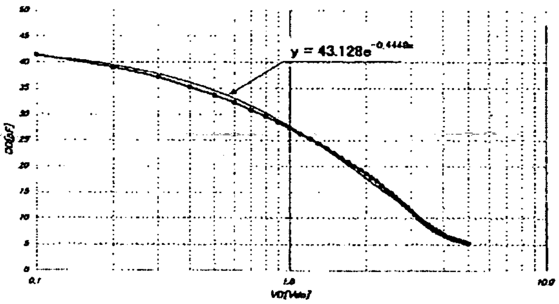
【図７】



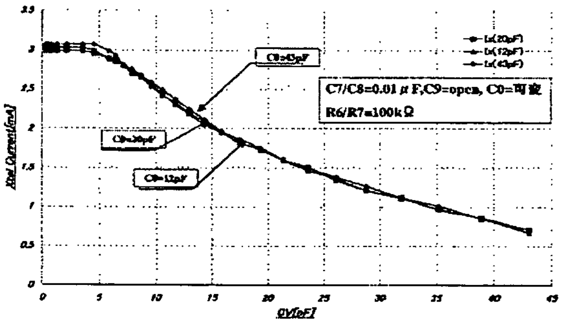
【図８】



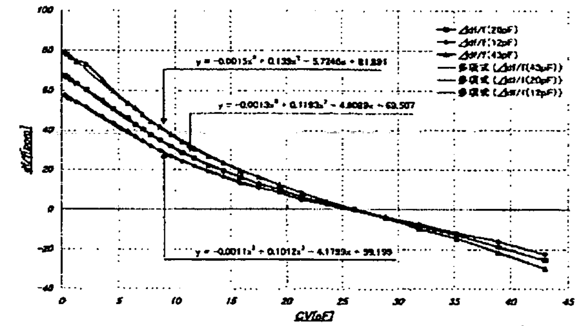
【図９】



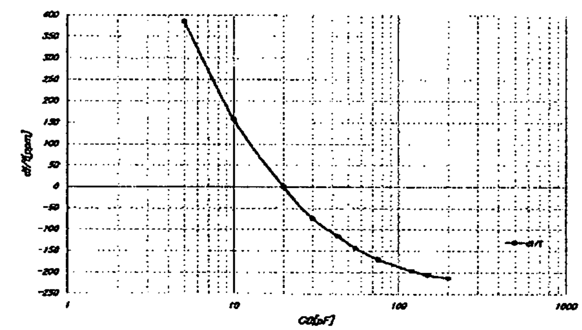
【図１０】



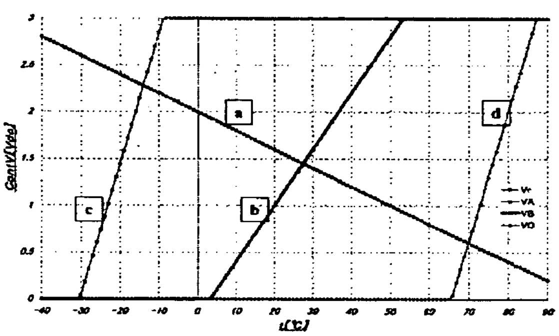
【図１１】



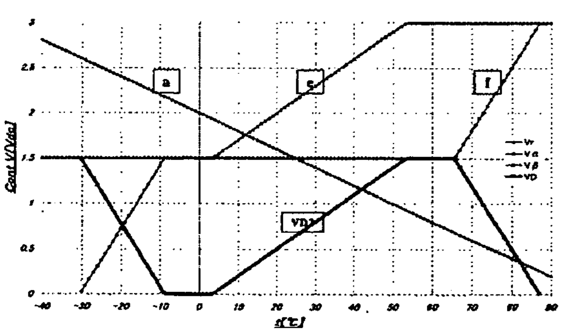
【図１２】



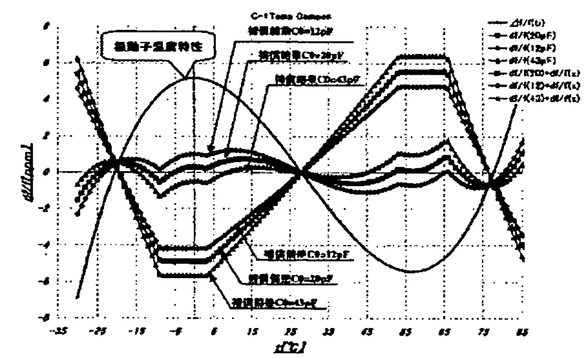
【図１３】



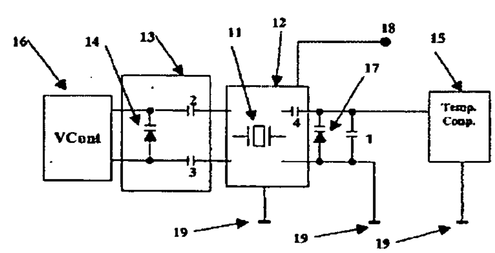
【図１４】



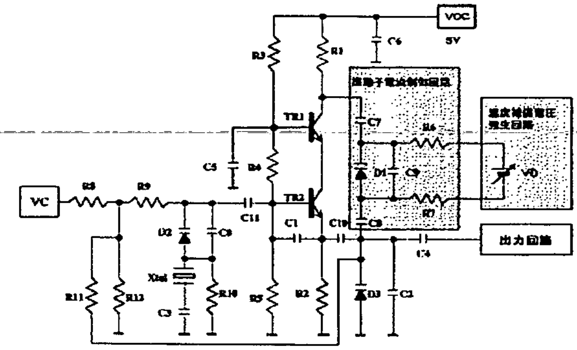
【図１５】



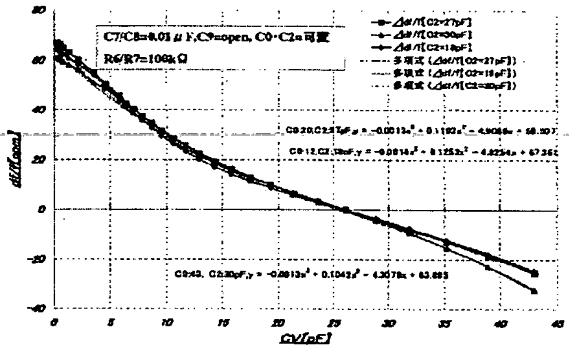
【図１６】



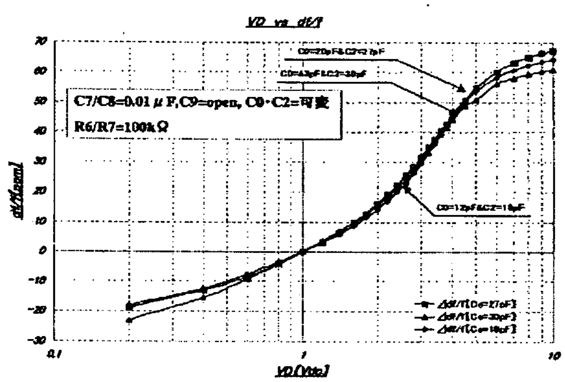
【図１７】



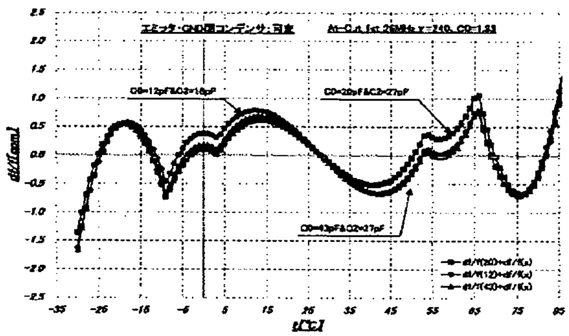
【図１９】



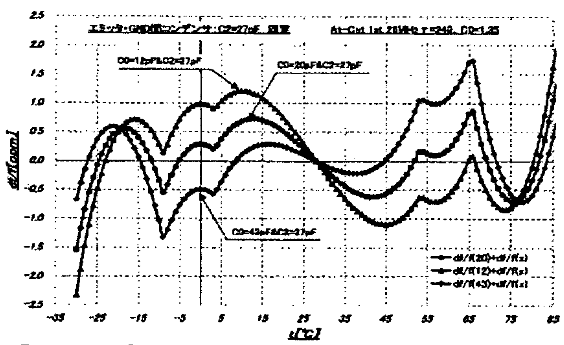
【図１８】



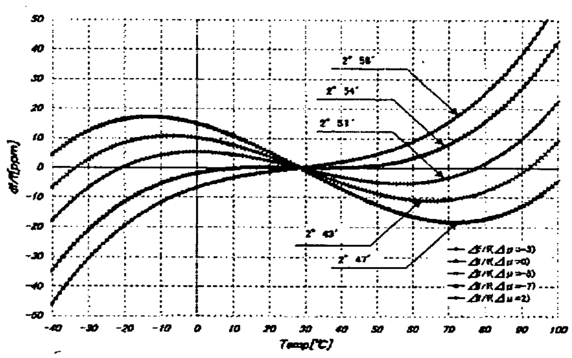
【図２０】



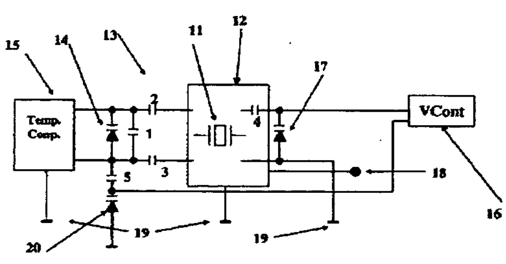
【図２１】



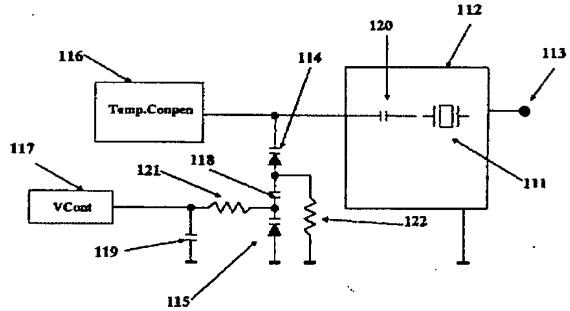
【図２３】



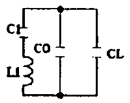
【図２２】



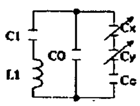
【図２４】



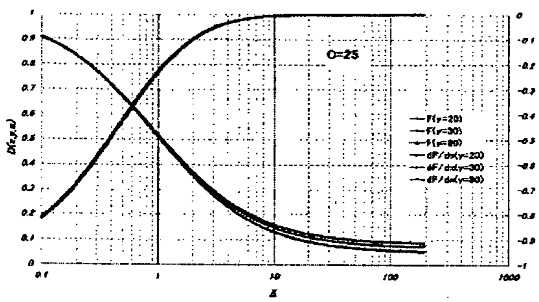
【図２５】



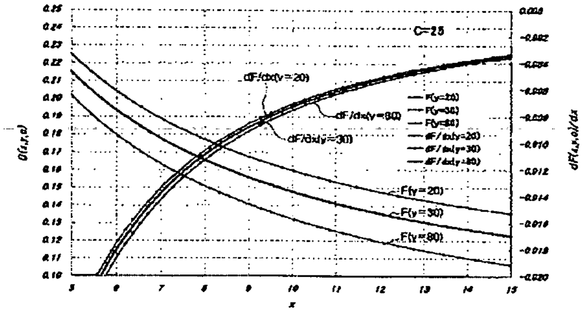
【図２６】



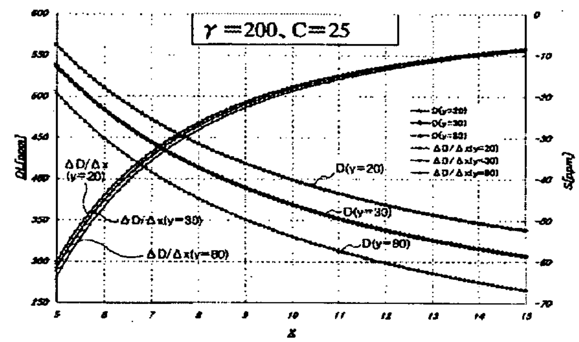
【図２７】



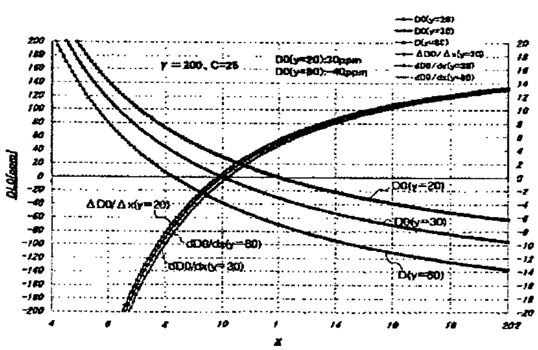
【図２８】



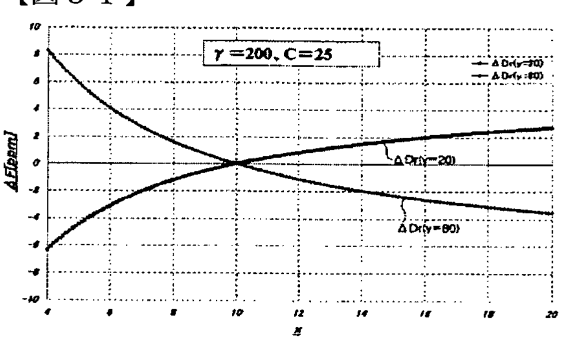
【図２９】



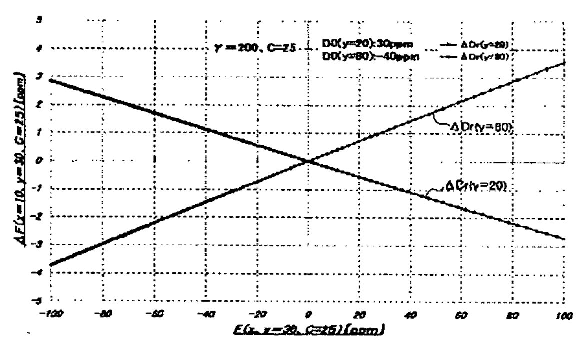
【図３０】



【図３１】



【図３２】



OIPE
OCT 19 2005
IAP57
PATENT & TRADEMARK OFFICE

* NOTICES *

JPO and NCIPI are not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.**** shows the word which can not be translated.

3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1]

It has the oscillator circuit which has the amplifier for an oscillation which a current is passed [amplifier] to the piezoelectric transducer equipped with the piezoelectric device excited on a predetermined frequency, and said piezoelectric device, and makes them excite said piezoelectric device, the vibrator current control section which controls the current of said piezoelectric transducer, the temperature-compensation circuit which compensates the temperature characteristic of said piezoelectric transducer, and the variable capacitance diode which carries out adjustable [of the load-carrying capacity of said oscillator circuit] with foreign voltage, and carries out adjustable [of the oscillation frequency],

Said temperature-compensation circuit is a temperature compensation piezo oscillator characterized by carrying out adjustable [of the oscillation frequency of said oscillator circuit] by controlling said vibrator current, carrying out adjustable [of the oscillation frequency of said oscillator circuit], compensating the temperature characteristic of said piezoelectric transducer and carrying out adjustable [of the applied voltage of said variable capacitance diode] with said foreign voltage by generating the function electrical potential difference which compensates the temperature characteristic of said piezoelectric transducer, and

inputting this function electrical potential difference into said vibrator current control section.

[Claim 2]

It has the oscillator circuit which has the amplifier for an oscillation which a current is passed [amplifier] to the piezoelectric transducer equipped with the piezoelectric device excited on a predetermined frequency, and said piezoelectric device, and makes them excite said piezoelectric device, the vibrator current control section which controls the current of said piezoelectric transducer, the temperature-compensation circuit which compensates the temperature characteristic of said piezoelectric transducer, and the variable capacitance diode which carries out adjustable [of the load-carrying capacity of said oscillator circuit] with foreign voltage, and carries out adjustable [of the oscillation frequency],

Said temperature-compensation circuit is a temperature compensation piezo oscillator characterized by carrying out adjustable [of the oscillation frequency of said oscillator circuit] by carrying out adjustable [of the oscillation frequency of said oscillator circuit], compensating the temperature characteristic of said piezoelectric transducer and carrying out adjustable [of the electrical potential difference inputted into said vibrator current control section with said foreign voltage] by generating the function electrical potential difference which compensates the temperature characteristic of said piezoelectric transducer, impressing this function electrical potential difference to said variable capacitance diode, and carrying out adjustable [of the load-carrying capacity of said oscillator circuit].

[Claim 3]

The temperature compensation piezo oscillator according to claim 1 or 2 characterized by inserting further the reactive element which carries out adjustable [of the oscillation frequency of said oscillator circuit] by carrying out adjustable [of the load-carrying capacity] to the load of said oscillator circuit.

[Claim 4]

The temperature compensation piezo oscillator according to claim 1 or 2 characterized by making the oscillation frequency of said oscillator circuit controllable by inserting further in the load of said oscillator circuit the variable reactive element which carries out adjustable [of the oscillation frequency of said oscillator circuit] by carrying out adjustable [of the load-carrying capacity], and carrying out adjustable [of the capacity of said variable reactive element] to it from the oscillator exterior concerned.

[Claim 5]

It has further the variable capacitance diode for amendment which amends compensation distortion generated by carrying out adjustable [of the load-carrying capacity],

Said variable capacitance diode for amendment is a temperature compensation piezo oscillator according to claim 1 characterized by supposing that it works so that compensation distortion generated by carrying out adjustable [of the load-carrying capacity of said vibrator current control section] with the function electrical potential difference generated by said temperature-compensation circuit may be amended.

[Translation done.]

* NOTICES *

JPO and NCIPI are not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.**** shows the word which can not be translated.

3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

This invention relates to the temperature-compensation approach of the piezo oscillator used as reference frequency of the land mobile communication link field and the satellite communication field in more detail about a temperature compensation piezo oscillator.

[0002]

[Description of the Prior Art]

In recent years, expansion of the use range of the land-mobile band communication link represented by the cellular phone is being enhanced. In connection with it, the spread of cellular phones is also frightful, ED competition is intensifying, and a miniaturization and low-cost-izing, and also high performance-ization are demanded also for the crystal oscillator used for a cellular phone. As a quartz resonator is shown in drawing 2323 , the 3rd oscillation frequency changes rounded to change of ambient temperature. For this reason, although the temperature-compensation circuit for offsetting the temperature characteristic of vibrator is established in the oscillator circuit and there are a direct temperature-compensation method and an indirect temperature-compensation method as temperature-compensation method in order to obtain high stability, it is common to carry out adjustable [of the load-carrying capacity of an oscillator circuit] also in which method, and to perform temperature compensation. Moreover, since a current oscillator uses it for a PLL circuit (phase lock loop) etc., connecting, addition of the function (Vcont) which impresses an electrical potential difference and carries out adjustable [of the frequency] is more indispensable than the exterior. That is, two or more adjustable functions for carrying out adjustable [of the load-carrying capacity], and changing a frequency will be prepared in an oscillator circuit. These functions will cause interference in the adjustable range inevitably. For example,

since the ratio of the addition capacity of the temperature-compensation circuit to the whole addition capacity will replace if it performs the external adjustable one of 20 ppm there when you need 100 ppm by change of addition capacity as an amount of temperature compensation, the frequency variation to change of addition capacity may change, it may become the amount of temperature compensation which is 99 ppm, and 1 ppm of temperature characteristics are made to get worse.

[0003]

The block diagram of the conventional temperature-compensated crystal oscillator with an external adjustable function is shown in drawing 24 .

The temperature-compensation electrical-potential-difference generating section 116 generates a compensation function electrical potential difference, and impresses it to variable capacitance diode 114. The load-carrying capacity of an oscillator circuit changes based on capacity change of this diode, and since it is controlled so that the temperature characteristic of the oscillation frequency of a quartz resonator 111 becomes a flat by this, the frequency temperature characteristic of an oscillator is made into the outstanding thing. in this case, the external adjustable (Vcont) one -- it carries out adjustable [of the frequency] by inputting an electrical potential difference and impressing from 117, to variable capacitance diode 115. An oscillation frequency not only changes with this, but it affects the amount of temperature compensation.

It is shown below that there is relation strong against the capacity factor (gamma=C 0 / C1) of vibrator to the amount of temperature compensation and an external good variate.

1. Basic Theory

The offset frequency deviation from the series resonating frequency at the time of the oscillation of a crystal oscillator is shown in a formula (1).

$$\cdots\cdots D_L = \frac{1}{2} \times \frac{C_1}{(C_0 + C_L)} \cdots\cdots (1)$$

$\cdots\cdots D_L$: 発振周波数偏差

C_1 : 振動子の直列容量

C_0 : 振動子の並列容量

C_c : 回路の容量

The oscillation frequency equivalence block diagram which a formula (1) shows to drawing 25 is shown.

It is drawing 26 which divided CL into Cx and three serial dosages of Cy and Cc as shown in a formula (2).

$$\cdots\cdots \frac{1}{C_L} = \frac{1}{C_x} + \frac{1}{C_y} + \frac{1}{C_c} \cdots\cdots (2)$$

For example, temperature-compensation capacity and Cy can be made into frequency regulation or external variable capacity, and Cc can make Cx oscillator-circuit capacity. Here, if C 0= 0 (Open), it will become convertible [(3) types].

$$D_L = \frac{C_1}{2C_L} = \frac{C_1}{2}\left(\frac{1}{C_x} + \frac{1}{C_y} + \frac{1}{C_c}\right) = \frac{C_1}{2C_x} + \frac{C_1}{2C_y} + \frac{C_1}{2C_c} \cdots\cdots (3)$$

That is, since the shift amount from a series resonating frequency is added to the capacity of Cx, Cy, and each Cc, respectively, frequency deviation does not receive interference of oppression etc. to each capacity change.

However, since piezoelectric devices, such as a quartz resonator, need the electrode for urging vibration, interelectrode capacity:C0 cannot surely be excluded.

(1) Obtain (4) types from a formula and (2).

$$D_L = \frac{C_1}{2(C_0 + C_L)} = \frac{C_1}{2C_0\left(1+\frac{C_L}{C_0}\right)} = \frac{1}{2\gamma\left(1+\frac{1}{\frac{C_0}{C_L}}\right)} = \frac{1}{2\gamma\left(1+\frac{1}{\frac{1}{x}+\frac{1}{y}+\frac{1}{c}}\right)} = \frac{1}{2\gamma} \times \frac{x+y+\frac{xy}{c}}{x+y+xy+\frac{xy}{c}} \cdots\cdots\cdots (4)$$

$$D_L = \frac{1}{2\gamma}F(x,y,c) \cdots\cdots\cdots\cdots\cdots\cdots DS_x = \frac{1}{2\gamma}\frac{dF}{dx}$$

$$F(x,y,c) = \frac{x+y+\frac{xy}{c}}{x+y+xy+\frac{xy}{c}}, \cdots\cdots\cdots S_x = \frac{dF}{dx} = \frac{-c^2y^2}{\{xy + c(x+y+xy)\}^2} \cdots\cdots\cdots\cdots\cdots (5)$$

$$\gamma = \frac{C_0}{C_1}, \ldots x = \frac{C_x}{C_0}, y = \frac{C_y}{C_0}, c = \frac{C_c}{C_0} \cdots\cdots\cdots\cdots\cdots (6)$$

$F(x,y,c)$: 正規化関数、$\frac{1}{2\gamma} = 1$とする、即ち、最大化変幅 = 1 とする周波数偏差を 示す。

S_x: $F(x,y,c)$を偏微分した値、 x の感度（単位変化あたりの周波数偏差）を示す。

γ: 容量比、x: 正規化可変容量1, y: 正規化可変容量2、 c：発振回路容量

[0004]

It carries out to c= 25, y= 20, and 30 and 80 at drawing 27 , and adjustable and the simulation Fig. of F (x y, c) are shown for x. Moreover, the enlarged drawing of this drawing is shown in drawing 28 . This drawing shows that sensibility is large and the variation of normalized frequency deflection is large in the field where x is small.

Drawing 29 is drawing showing the frequency deviation DL (x y, c) and Sx at the time of carrying out to gamma= 200, i.e., maximization **** 1/2gamma=2500ppm. Drawing 30 is drawing showing the frequency deviation on the basis of DL at the time of being referred to as x= 10. Drawing 31 is drawing showing the difference

of DL [as opposed to / as opposed to / in the gap from DL curve at the time of being referred to as x= 10 by y= 30, y= 30 / i.e., /, / x= 10 / the value of x of each curve of x= 10 at y= 80]. That is, this is the gap from the criteria curve to the value of x, namely, serves as the amount of interference. It is shown that the deflection of each curve becomes large, so that from this drawing and the value of x is small.

The axis of ordinate of drawing 32 shows the deflection of the gap from the criteria curve of drawing 31 , and an axis of abscissa shows the frequency deviation at the time of being referred to as y= 30 on the basis of x= 10 of drawing 30 , i.e., the value of DL. When the -100 ppm frequency which will be distorted about about 1 ppm if in the case of drawing 32 a -40 ppm frequency is lowered [x (variable capacity 1)] and a 30 ppm frequency is raised in y (variable capacity 2) is lowered, about 2.8 ppm will be distorted.

It turns out that this is the matter which should be taken into consideration about the oscillator containing adjustable [two], i.e., the temperature-compensation functional addition to OCXO (Takayasu a law oscillator), the temperature-compensation functional addition to VCXO (voltage controlled oscillator), the Voltage Cont (armature-voltage control function) addition to TCXO (temperature-compensation oscillator), etc.

[0005]

[Problem(s) to be Solved by the Invention]

In order to carry out adjustable [of the load-carrying capacity, such as an external control function of a frequency, and a temperature-compensation function,] like said drawing 24 , there is a big technical problem that adjustable [mutual] gives distortion to a good variate or the amount of compensation in an oscillator equipped with two or more load-carrying capacity adjustable functions. Moreover, the oscillation frequency of a quartz resonator can carry out adjustable greatly with load-carrying capacity, ambient temperature, and three elements of a vibrator current. In this, adjustable [of the frequency by the load-carrying capacity adjustable / most] is used. Moreover, in the Takayasu constant

oscillator, high stability has been obtained by making temperature of vibrator and a circumference circuit regularity. However, most examples of carrying out adjustable using a vibrator current cannot be found, and the circuit which oppresses a vibrator current with some high stability oscillators for a secular-change improvement is prepared.

So, it is going to compensate the frequency temperature characteristic of a quartz resonator with this invention by controlling a vibrator current using the frequency control by the vibrator current hardly affecting the good variate of load-carrying capacity.

In the oscillator equipped with two or more load-carrying capacity adjustable functions by controlling a vibrator current in view of this technical problem, this invention aims at offering the temperature compensation piezo oscillator which can acquire high temperature stability while it can obtain the big adjustable range which is not in the former.

[0006]

[Means for Solving the Problem]

In order that this invention may solve this technical problem, claim 1 The oscillator circuit which has the amplifier for an oscillation which a current is passed [amplifier] to the piezoelectric transducer equipped with the piezoelectric device excited on a predetermined frequency, and said piezoelectric device, and makes them excite said piezoelectric device, The vibrator current control section which controls the current of said piezoelectric transducer, and the temperature-compensation circuit which compensates the temperature characteristic of said piezoelectric transducer, It has the variable capacitance diode which carries out adjustable [of the load-carrying capacity of said oscillator circuit] with foreign voltage, and carries out adjustable [of the oscillation frequency]. Said temperature-compensation circuit By generating the function electrical potential difference which compensates the temperature characteristic of said piezoelectric transducer, and inputting this function electrical potential difference into said vibrator current control section It is characterized by carrying out

adjustable [of the oscillation frequency of said oscillator circuit] by controlling said vibrator current, carrying out adjustable [of the oscillation frequency of said oscillator circuit], compensating the temperature characteristic of said piezoelectric transducer and carrying out adjustable [of the applied voltage of said variable capacitance diode] with said foreign voltage.

In order to use the conventional oscillator for a PLL circuit (phase lock loop) etc., connecting, two or more adjustable functions for carrying out adjustable [of the load-carrying capacity], and changing a frequency will be prepared in an oscillator circuit. These functions will cause interference in the adjustable range inevitably. Then, by generating a function electrical potential difference by the temperature-compensation circuit, and controlling a vibrator current by this invention, the temperature characteristic of a piezoelectric transducer is compensated by making the oscillation frequency of an oscillator circuit adjustable, and adjustable [of a frequency] uses the variable capacitance diode with which capacity serves as adjustable by impressing foreign voltage in the load-carrying capacity of an oscillator.

Since the temperature characteristic is compensated by controlling a vibrator current according to this invention, while being able to obtain the big adjustable range in an oscillator equipped with two or more load-carrying capacity adjustable functions, high temperature stability can be acquired without giving interference to the mutual adjustable range.

The oscillator circuit which has the amplifier for an oscillation which claim 2 passes [amplifier] a current to the piezoelectric transducer equipped with the piezoelectric device excited on a predetermined frequency, and said piezoelectric device, and excites said piezoelectric device, The vibrator current control section which controls the current of said piezoelectric transducer, and the temperature-compensation circuit which compensates the temperature characteristic of said piezoelectric transducer, It has the variable capacitance diode which carries out adjustable [of the load-carrying capacity of said oscillator circuit] with foreign voltage, and carries out adjustable [of the oscillation frequency]. Said

temperature-compensation circuit By generating the function electrical potential difference which compensates the temperature characteristic of said piezoelectric transducer, impressing this function electrical potential difference to said variable capacitance diode, and carrying out adjustable [of the load-carrying capacity of said oscillator circuit] It is characterized by carrying out adjustable [of the oscillation frequency of said oscillator circuit] by carrying out adjustable [of the oscillation frequency of said oscillator circuit], compensating the temperature characteristic of said piezoelectric transducer and carrying out adjustable [of the electrical potential difference inputted into said vibrator current control section with said foreign voltage].

Although the temperature-compensation circuit which compensates the temperature characteristic is connected to a vibrator current control section and temperature compensation is performed in claim 1, in this invention, by impressing the function electrical potential difference generated in the temperature-compensation circuit to variable capacitance diode, adjustable [of the oscillation frequency] is carried out and temperature compensation is performed. Moreover, it performs adjustable [of a frequency] by impressing foreign voltage to a vibrator current control section.

According to this invention, the same operation effectiveness as claim 1 is done so.

[0007]

Claim 3 is characterized by inserting further the reactive element which carries out adjustable [of the oscillation frequency of said oscillator circuit] by carrying out adjustable [of the load-carrying capacity] to the load of said oscillator circuit. By carrying out adjustable [of the load-carrying capacity of an oscillator circuit], the inclination of the frequency deviation when impressing a temperature-compensation electrical potential difference changes. In other words, an oscillation frequency is changeable by carrying out adjustable [of the load-carrying capacity].

Since the reactive element which carries out adjustable [of the oscillation

frequency] was inserted further according to this invention, an oscillation frequency can be changed by easy circuitry.

Claim 4 is characterized by making the oscillation frequency of said oscillator circuit controllable by inserting further in the load of said oscillator circuit the variable reactive element which carries out adjustable [of the oscillation frequency of said oscillator circuit] by carrying out adjustable [of the load-carrying capacity], and carrying out adjustable [of the capacity of said variable reactive element] to it from the oscillator exterior concerned.

If the capacity can carry out adjustable [of the reactive element] to arbitration like adjustable Tolima, adjustable [of the Tolima] is carried out from the exterior, and an oscillation frequency can be controlled.

Since the variable reactive element which can carry out adjustable [of the reactive element] to arbitration like adjustable Tolima is used according to this invention, an oscillation frequency is easily controllable from the outside.

Claim 5 is further equipped with the variable capacitance diode for amendment which amends compensation distortion generated by carrying out adjustable [of the load-carrying capacity], and said variable capacitance diode for amendment is characterized by supposing that it works so that compensation distortion generated by carrying out adjustable [of the load-carrying capacity of said vibrator current control section] with the function electrical potential difference generated by said temperature-compensation circuit may be amended.

According to this invention, since a vibrator current control section is equipped with the variable capacitance diode for amendment, compensation distortion generated by carrying out adjustable [of the load-carrying capacity] can be amended, and the frequency deviation to applied voltage can be reduced further.

[0008]

[Embodiment of the Invention]

Hereafter, this invention is explained to a detail using the operation gestalt shown in drawing. However, the component indicated by this operation gestalt, a class, combination, a configuration, its relative configuration, etc. are not the main point

that limits the range of this invention only to it but only the mere examples of explanation, as long as there is no specific publication.
Generally, since the relation of a quartz resonator between the stress and distortion of Xtal is nonlinear, it is confirmed that resonance frequency changes with the vibrator currents as follows.

..................$\dfrac{\Delta f}{f} = Ki^2$

..................i:振動子電流

................K:カット・振動モード・電極寸法・・・等で決まる固有定数

as the approach of controlling the vibrator current at the time of this oscillation -- some Takayasu -- a law -- although inserted with the crystal oscillator (OCXO) for a secular-change improvement of an AGC circuit, it is complicated in circuit and is not practical.
Here, temperature-compensation simulation is performed using a vibrator current being controllable by using the circuit indicated by 2002 to application-for-patent 265000 official report by the same applicant.
[0009]
Drawing 1 is the block diagram of the temperature compensation method of this invention. The oscillator circuit 12 which has the amplifier for an oscillation which this temperature-compensation method passes [amplifier] a current to the quartz resonator 11 equipped with the piezoelectric device excited on a predetermined frequency, and a piezoelectric device, and excites a piezoelectric device, and which is not illustrated, It has the vibrator current control circuit 13 which controls the current of a quartz resonator 11, the temperature-compensation electrical-potential-difference generating circuit 15 which compensates the temperature characteristic of said piezoelectric transducer 11, and the variable capacitance diode 17 for external adjustable by which adjustable is carried out on the external adjustable electrical potential difference 16 in the oscillation frequency of an oscillator circuit 12, and is constituted. In addition, the

trembler current control circuit 13 is constituted by the variable capacitance diode 14 for trembler current control, and capacitors 1-3.
Outline actuation of this block diagram generates the function electrical potential difference which the temperature-compensation electrical-potential-difference generating circuit 15 compensates for the temperature characteristic of a quartz resonator 11, and this vibrator current control circuit 13 compensates the temperature characteristic of a quartz resonator 11 by controlling the vibrator current of a quartz resonator 11 and making the oscillation frequency of an oscillator circuit 12 adjustable by impressing this function electrical potential difference to the vibrator current control circuit 13.
Drawing 2 is drawing showing the example of an operation circuit. Since the same reference number is given to the same component, the overlapping explanation is omitted. Here, each constant was set up as follows.
R1=390ohm, R2=1kohm, R3/R4=10kohm, R5=20kohm, R6/R7=100kohm, the C0= adjustable, 2= 27pF of C1/C, 3= 100pF of C, 4= 10pF of C, 6= 10000pF of C5/C, 7= 0pF of C, 9= 0.1 micro F of C8/C, TR1/TR2=2SC3732, D1=MA2S304, Xtal=26 MHz-At-Cut1st, VCC=5Vdc, VD= DC power supply, a V.V= high frequency voltmeter, a Freq.C.= electronic counter
An oscillator circuit is the Colpitts oscillator circuit of cascode connection, and supplies an oscillation output to the vibrator current control circuit 13 which made insertion connection between the collector of a transistor TR1, and the emitter of a transistor TR2. Moreover, the temperature-compensation electrical-potential-difference generating circuit 15 is connected to the vibrator current control circuit 13 through resistance R6 and R7, and a function electrical potential difference is supplied.
[0010]
Drawing 3 is the circuit diagram of the temperature-compensation electrical-potential-difference generating circuit 15 of this invention, and the circuit diagram of the vibrator current control circuit 13. Since the same reference number is given to the same component, the overlapping explanation is omitted. Moreover,

the constant at the time of the simulation of the temperature-compensation electrical-potential-difference generating circuit 15 is shown below.

R1, 3 and 4=10kohm, R2=6.5ohm, R5= adjustable setting, D1=1S953, IC1=TC75S51FU

R10=10kohm, R11=30kohm, IC2= TC75S51FU

R12=10kohm, R13=140kohm, IC3= TC75S51FU

R14=10kohm, R15=140kohm, IC4= TC75S51FU

R6=9.6kohm, R7=11.1kohm, R8=11.3kohm, R9=8kohm,

R16, 17, 18, 21 and 22=100kohm, R19 and 20=200kohm, D2=MA2S304, C 3-4, 5= 0.1 micro F

Xtal=13MHz, gamma= 240, 0= 1.35pF of C, Cp=40pF, Cs=35pF

Vcc=3.0V,

[0011]

Drawing 4 carries out adjustable [of the applied voltage to variable capacitance diode D1] by being referred to as 0= 20pF of C, and carrying out adjustable [of the electrical potential difference of VD]. An axis of ordinate shows the deflection on the basis of the frequency when being referred to as VD=1V, and an axis of abscissa shows the applied voltage to VD and variable capacitance diode D1. A result when drawing 5 sets to 0= 12pF of C and drawing 6 sets to 0= 43pF of C is shown similarly. It turns out that the oscillation frequency and the vibrator current are also carrying out same change from each drawing to the applied voltage of D1.

A vibrator current is searched for by (7) formulas.

$$I_X(\text{Xtal Current}) = \omega CV \quad \text{.........} (7)$$

V：C_3の両端電圧： VV　単位rms

C：C_3の容量 :100pF

$\omega = 2\pi f \qquad f = 26\text{MHz}$

Drawing 7 shows change of the vibrator current which makes a parameter each

C0 to change of VD. This drawing shows that change of a vibrator current is hardly based on the value of C0.

Drawing 8 shows the frequency deviation which makes a parameter each C0 to change of VD. It turns out that variation changes with values of C0 clearly from this drawing although it is small.

Drawing 9 is drawing in which showing the applied-voltage pair capacity change property of variable-capacitance-diode D1:MA2S304, and showing observation data and its approximation function. This drawing shows that it is well in agreement in an approximation function.

Drawing 10 is drawing showing the vibrator current over capacity change of variable capacitance diode D1. This drawing shows hardly being influenced by change of capacity C0.

Drawing 11 shows the frequency deviation to capacity change of variable capacitance diode D1. However, it is based on VD=1Vdc and valve flow coefficient=26pF. Moreover, the approximation function which made each C0 the parameter is shown.

drawing 12 -- capacity: -- it is drawing showing the oscillation frequency change at the time of carrying out adjustable [of C0]. However, it is based on 0= 20pF of C. Moreover, D1 capacity is made into VD=1Vdc, i.e., valve flow coefficient=26pF. If it carries out adjustable from this result to 0= 43pF of C0=12 pF-C, about 280 ppm change will be obtained as frequency deviation.

[0012]

Drawing 13 is drawing showing the simulation result in this circuit constant. Each notation of drawing shows electrical-potential-difference change of each notation of drawing 3 .

[a] shows monotone reduction to a temperature change with the output of an operational amplifier IC 1.

[b] shows the increment in monotone to about 50 degrees C from about 0 degree C which compensates change near the point of inflection of vibrator with the output of an operational amplifier IC 2.

[c] shows the increment in monotone from about -30 degrees C to about -10 degrees C which compensates a side with the output of an operational amplifier IC 3 whenever [low-temperature / of vibrator].
[d] shows the increment in monotone from about 65 degrees C to about 90 degrees C which compensates the high temperature side of vibrator with the output of an operational amplifier IC 4.
Electrical-potential-difference change of each part of the temperature-compensation electrical-potential-difference generating circuit 15 of drawing 3 is shown as well as drawing 14 . [e] shows electrical-potential-difference change which compounded [b] and Vcc. [f] shows electrical-potential-difference change which compounded [c] and [d]. [VD] shows the electrical-potential-difference change between the cathode anodes of variable capacitance diode.
[0013]
Drawing 15 is the result of carrying out simulation of the temperature compensation according to the oscillation frequency deviation by change of variable-capacitance-diode:D1 for vibrator current control based on drawing 11 . That is, the compensation electrical potential difference from the temperature-compensation electrical-potential-difference generating circuit 15 is received by variable-capacitance-diode:D1 for vibrator current control, and it considers as capacity change of the vibrator current control circuit 13. The juxtaposition capacity C7 and C8 which compensates the temperature characteristic of vibrator appropriately, and C9 are set up from the relational expression of the capacity change pair frequency deviation which makes C0 a parameter from drawing 11 . In this simulation, temperature-compensation simulation is performed by setting it as 0= 20pF of 1.C at a setup, 7= 5pF of C, and 9= 66pF of C8/C. Consequently, the temperature-compensation property of **2 ppm or less is acquired at -30 degrees C - +85 degrees C.
2. With the above-mentioned setup, change 0= 12pF as ["namely, as it was set as 7= 5pF of C, and 9= 66pF of C8/C" / C and C / 0= 43pF]. As a result, it falls by frequency the rise of about 0.8 ppm at 0= 12pF of C, and falls the frequency of

about 0.8 ppm by about 55 degrees C at about 0 degree C. Moreover, it goes up by frequency the fall of about 1 ppm at 0= 43pF of C, and goes up the frequency of about 1 ppm in about 55 degrees C at about 0 degree C.
Furthermore, it falls to a +150 ppm rise and 0= 43pF of C0=20 pF->C by -130 ppm with the load-carrying capacity adjustable from 0 pair of C frequency deviation result of drawing 12 by the load-carrying capacity adjustable of 0= 12pF of C0=20 pF->C.
That is, it is the result of the ability not obtaining in the temperature compensation and the external adjustable one only by the conventional load-carrying capacity adjustable.
Drawing 16 is the block diagram of other examples of the temperature compensation method of this invention. Since the same reference number is given to the same component, the overlapping explanation is omitted. The point that drawing 16 differs from drawing 1 is a point that the locations of external adjustable 16 differ as the temperature-compensation electrical-potential-difference generating circuit 15. namely, the external adjustable one -- the vibrator current control circuit 13 is controlled by 16, adjustable [of the variable capacitance diode 17] is carried out by the temperature-compensation electrical-potential-difference generating circuit 15, and temperature compensation is carried out.
As mentioned above, this invention performs frequency change for compensating the temperature characteristic of a quartz resonator by controlling a vibrator current, and when adjustable [of the frequency] needs to be carried out by external control, it makes it load-carrying capacity adjustable as usual.
Since each interference is lost by doing in this way, frequency change especially by the external adjustable one can be enlarged. Moreover, the temperature characteristic which was excellent since there was little interference to the amount of temperature compensation by the external adjustable one can also be acquired. It is predicted that this contributes to functional expansion of a future crystal oscillator or a piezo oscillator greatly.

[0014]

Drawing 17 is drawing showing the circuit which amends the difference (compensation distortion by the load-carrying capacity adjustable) of the frequency deviation by the applied voltage to the vibrator current control variable capacitance diode D1 by the value of load-carrying capacity as a result of being shown in drawing 8 . The controlled variable of the vibrator current control system by this invention is decided by the ratio of the capacity between collector emitters, and an emitter and the capacity between GND, and to the capacity between collector emitters, a controlled variable becomes large, so that an emitter and the capacity between GND are small.

From this, the compensation distortion by the load-carrying capacity adjustable in accordance with controlling variable capacitance diode D2 can be amended by controlling a variable reactive element (variable capacitance diode D2) by adjustable [of foreign voltage Vc], inserting a variable reactive element (variable capacitance diode D3) between an emitter and GND, and carrying out adjustable [of the capacity of this diode] with foreign voltage Vc at the same time it carries out adjustable [of the frequency] by carrying out adjustable [of the load-carrying capacity]. In this case, making load-carrying capacity small and carrying out adjustable [of the frequency] highly and making capacity between an emitter and GND small, increasing the amount of compensation, and performing distortion amendment are making load-carrying capacity small further, and it is big effectiveness that amendment strain control can be performed in the same control as the frequency adjustable.

Drawing 18 is the result of measuring by performing the following cure to the capacitor C0 connected to a trembler at a serial.

0= 20pF -- emitter of C, and capacity between GND: It was referred to as an emitter and 2= 18pF of 0= 12pF [of C] -- capacity:C between GND, and 2= 30pF of 0= 43pF [of C] -- emitters and capacity:C between GND on the basis of 2= 27pF of C, amendment distortion was performed, and the frequency deviation by the applied voltage to the vibrator current control variable capacitance diode D1

was shown.
the result of drawing 8 before amendment -- before amendment -- VD=2Vdc -- receiving -- amount of differences (amount of distortion) = -- about 8 ppm -- receiving -- after amendment -- VD=2Vdc -- amount of differences (amount of distortion) = -- it is set to about 2 ppm and this serves as a distortion (dependency of capacity C0 in D1 applied-voltage pair frequency deviation property) improvement.
Drawing 19 is drawing showing the relation of the frequency deviation by the capacity change to the vibrator current control variable capacitance diode D1 at the time of performing distortion amendment.
Drawing 20 is drawing showing the temperature characteristic simulation result at the time of performing amendment distortion.
Drawing 21 is drawing showing the result before the temperature characteristic simulation of drawing 15 , i.e., distortion amendment.
clear from the above result -- as -- amount [before amendment] of distortion = -- about 1.6 ppm amends -- after [distortion amendment] = -- about 0.4 ppm -- about [an improvement and] -- being set to one fourth is shown.
[0015]
[Effect of the Invention]
Since the temperature characteristic is compensated by controlling a vibrator current according to invention of claim 1 like a publication, while being able to obtain the big adjustable range in an oscillator equipped with two or more load-carrying capacity adjustable functions above, high temperature stability can be acquired without giving interference to the mutual adjustable range.
Moreover, in claim 2, the same operation effectiveness as claim 1 is done so.
Moreover, at claim 3, since the reactive element which carries out adjustable [of the oscillation frequency] was inserted further, an oscillation frequency can be changed by easy circuitry.
Moreover, since the variable reactive element which can carry out adjustable [of the reactive element] to arbitration like adjustable Tolima is used, an oscillation

frequency is easily controllable by claim 4 from the outside.
Moreover, in claim 5, since a vibrator current control section is equipped with the variable capacitance diode for amendment, compensation distortion generated by carrying out adjustable [of the load-carrying capacity] can be amended, and the frequency deviation to applied voltage can be reduced further.

[Brief Description of the Drawings]

[Drawing 1] It is the block diagram of the temperature compensation method of this invention.

[Drawing 2] It is drawing of the circuit example of the temperature-compensation method of this invention.

[Drawing 3] It is drawing of the example of an operation circuit of the temperature-compensation method of this invention (compensation electrical-potential-difference generating circuit).

[Drawing 4] It is drawing showing the example -1 of an operation circuit of this invention, and a D1 applied-voltage pair frequency deviation & vibrator current.

[Drawing 5] It is drawing showing the example -2 of an operation circuit of this invention, and a D1 applied-voltage pair frequency deviation & vibrator current.

[Drawing 6] It is drawing showing the example -3 of an operation circuit of this invention, and a D1 applied-voltage pair frequency deviation & vibrator current.

[Drawing 7] It is drawing showing the example -4 of an operation circuit of this invention, and D1 applied-voltage pair vibrator current.

[Drawing 8] It is drawing showing the example -5 of an operation circuit of this invention, and D1 applied-voltage pair frequency deviation.

[Drawing 9] It is drawing showing the measurement result and approximation function of variable-capacitance-diode D1:MA2S304 of this invention.

[Drawing 10] It is drawing showing the example -6 of an operation circuit of this invention, and D1 variable-capacity pair vibrator current.

[Drawing 11] It is drawing showing the example -7 of an operation circuit of this invention, and D1 variable-capacity pair frequency deviation.

[Drawing 12] It is drawing showing the example -8 of an operation circuit of this

invention, and C0 variable-capacity pair frequency deviation.

[Drawing 13] It is drawing showing the example -9 of an operation circuit of this invention, and the temperature-compensation electrical-potential-difference generating circuit simulation result -1.

[Drawing 14] It is drawing showing the example -10 of an operation circuit of this invention, and the temperature-compensation electrical-potential-difference generating circuit simulation result -2.

[Drawing 15] It is drawing showing the temperature characteristic of example of operation circuit -11 vibrator of this invention, temperature-compensation frequency deviation, and the simulation result of compensation.

[Drawing 16] It is the block diagram of an example besides the temperature compensation method of this invention.

[Drawing 17] It is drawing showing the distortion amendment circuit example of a temperature-compensation method.

[Drawing 18] It is drawing showing invention circuit (with distortion amendment circuit) example-12D1 applied-voltage pair frequency deviation.

[Drawing 19] It is drawing showing invention circuit (with distortion amendment circuit) example-13D1 variable-capacity pair frequency deviation.

[Drawing 20] It is drawing showing the simulation result of invention circuit (with distortion amendment circuit) example -14 temperature compensation.

[Drawing 21] It is drawing showing the simulation result of invention circuit example -15 temperature compensation.

[Drawing 22] It is the block diagram of an invention temperature compensation method (with a distortion amendment circuit).

[Drawing 23] It is drawing showing the temperature characteristic simulation by difference of the cutting include angle of At-Cut vibrator.

[Drawing 24] It is the block diagram of a temperature compensation method conventionally.

[Drawing 25] It is resonance frequency equivalence block drawing 1.

[Drawing 26] It is resonance frequency equivalence block drawing 2.

[Drawing 27] It is an F(x y, c) &Sx simulation Fig.
[Drawing 28] It is an F(x y, c) &Sx simulation enlarged drawing.
[Drawing 29] It is a D(x y, c) &Sx simulation Fig.
[Drawing 30] It is a D(x y, c) &Sx simulation Fig.
[Drawing 31] It is deltaF (x y, c) simulation Fig.
[Drawing 32] It is a deltaF(x y, c) &F simulation Fig.
[Description of Notations]
11 Quartz Resonator and 12 Oscillator Circuit and 13 Vibrator Current Control Circuit and 14 Variable Capacitance Diode for Vibrator Current Control, and 15 Temperature-Compensation Electrical-Potential-Difference Generating Circuit and 16 The External Adjustable One and 17 Variable Capacitance Diode for External Adjustable, and 18 Output Circuit, 19 GND

[Translation done.]

* NOTICES *

JPO and NCIPI are not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the block diagram of the temperature compensation method of this invention.
[Drawing 2] It is drawing of the circuit example of the temperature-compensation

method of this invention.

[Drawing 3] It is drawing of the example of an operation circuit of the temperature-compensation method of this invention (compensation electrical-potential-difference generating circuit).

[Drawing 4] It is drawing showing the example -1 of an operation circuit of this invention, and a D1 applied-voltage pair frequency deviation & vibrator current.

[Drawing 5] It is drawing showing the example -2 of an operation circuit of this invention, and a D1 applied-voltage pair frequency deviation & vibrator current.

[Drawing 6] It is drawing showing the example -3 of an operation circuit of this invention, and a D1 applied-voltage pair frequency deviation & vibrator current.

[Drawing 7] It is drawing showing the example -4 of an operation circuit of this invention, and D1 applied-voltage pair vibrator current.

[Drawing 8] It is drawing showing the example -5 of an operation circuit of this invention, and D1 applied-voltage pair frequency deviation.

[Drawing 9] It is drawing showing the measurement result and approximation function of variable-capacitance-diode D1:MA2S304 of this invention.

[Drawing 10] It is drawing showing the example -6 of an operation circuit of this invention, and D1 variable-capacity pair vibrator current.

[Drawing 11] It is drawing showing the example -7 of an operation circuit of this invention, and D1 variable-capacity pair frequency deviation.

[Drawing 12] It is drawing showing the example -8 of an operation circuit of this invention, and C0 variable-capacity pair frequency deviation.

[Drawing 13] It is drawing showing the example -9 of an operation circuit of this invention, and the temperature-compensation electrical-potential-difference generating circuit simulation result -1.

[Drawing 14] It is drawing showing the example -10 of an operation circuit of this invention, and the temperature-compensation electrical-potential-difference generating circuit simulation result -2.

[Drawing 15] It is drawing showing the temperature characteristic of example of operation circuit -11 vibrator of this invention, temperature-compensation

frequency deviation, and the simulation result of compensation.

[Drawing 16] It is the block diagram of an example besides the temperature compensation method of this invention.

[Drawing 17] It is drawing showing the distortion amendment circuit example of a temperature-compensation method.

[Drawing 18] It is drawing showing invention circuit (with distortion amendment circuit) example-12D1 applied-voltage pair frequency deviation.

[Drawing 19] It is drawing showing invention circuit (with distortion amendment circuit) example-13D1 variable-capacity pair frequency deviation.

[Drawing 20] It is drawing showing the simulation result of invention circuit (with distortion amendment circuit) example -14 temperature compensation.

[Drawing 21] It is drawing showing the simulation result of invention circuit example -15 temperature compensation.

[Drawing 22] It is the block diagram of an invention temperature compensation method (with a distortion amendment circuit).

[Drawing 23] It is drawing showing the temperature characteristic simulation by difference of the cutting include angle of At-Cut vibrator.

[Drawing 24] It is the block diagram of a temperature compensation method conventionally.

[Drawing 25] It is resonance frequency equivalence block drawing 1.

[Drawing 26] It is resonance frequency equivalence block drawing 2.

[Drawing 27] It is an F(x y, c) &Sx simulation Fig.

[Drawing 28] It is an F(x y, c) &Sx simulation enlarged drawing.

[Drawing 29] It is a D(x y, c) &Sx simulation Fig.

[Drawing 30] It is a D(x y, c) &Sx simulation Fig.

[Drawing 31] It is deltaF (x y, c) simulation Fig.

[Drawing 32] It is a deltaF(x y, c) &F simulation Fig.

[Description of Notations]

11 Quartz Resonator and 12 Oscillator Circuit and 13 Vibrator Current Control Circuit and 14 Variable Capacitance Diode for Vibrator Current Control, and 15

Temperature-Compensation Electrical-Potential-Difference Generating Circuit and 16 The External Adjustable One and 17 Variable Capacitance Diode for External Adjustable, and 18 Output Circuit, 19 GND

[Translation done.]

* NOTICES *

JPO and NCIPI are not responsible for any damages caused by the use of this translation.

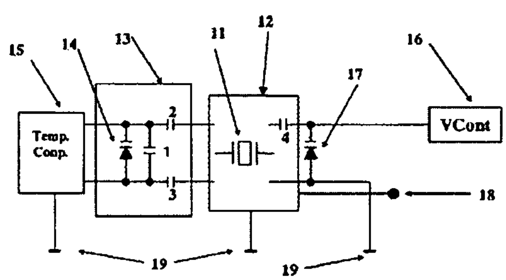
1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.**** shows the word which can not be translated.

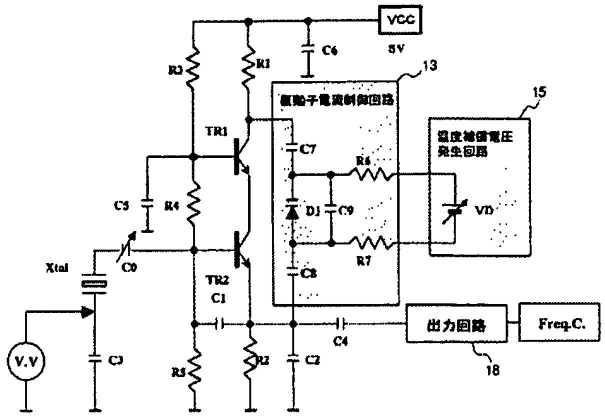
3.In the drawings, any words are not translated.

DRAWINGS

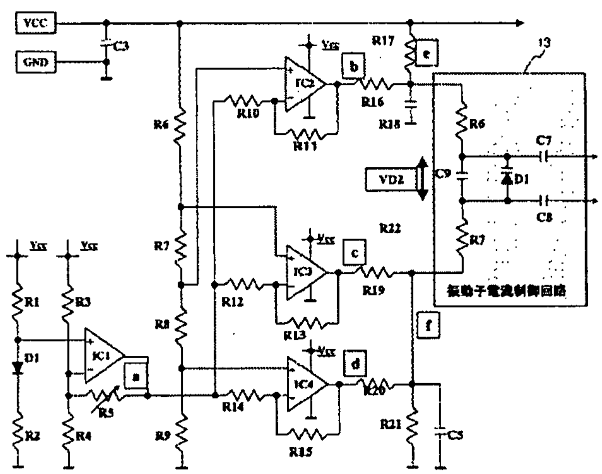
[Drawing 1]



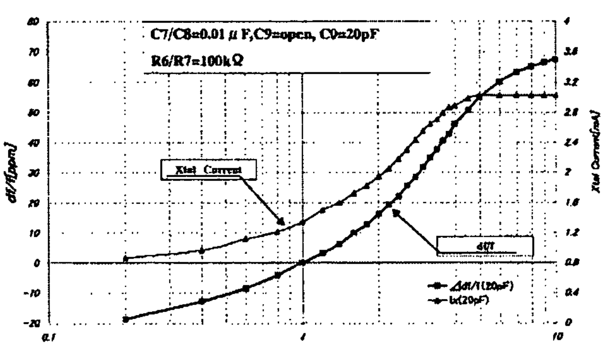
[Drawing 2]



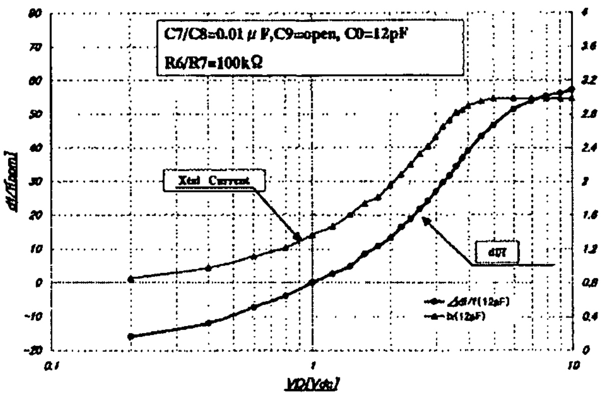
[Drawing 3]



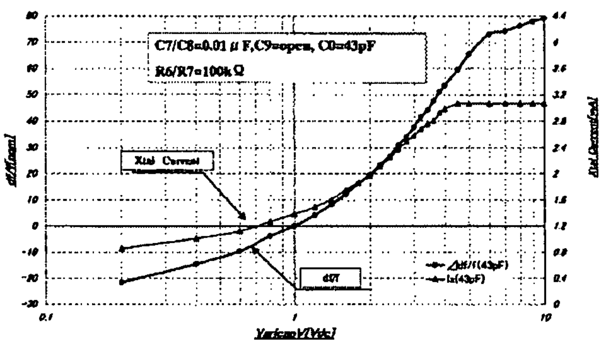
[Drawing 4]



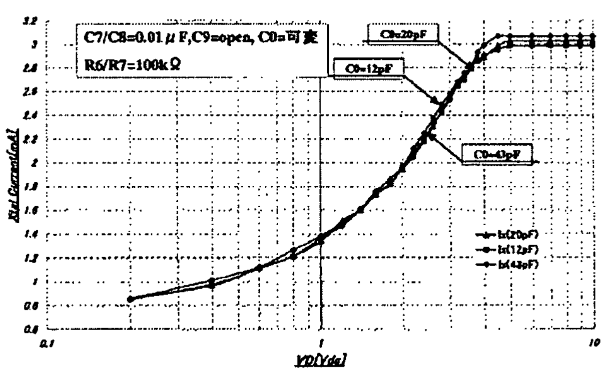
[Drawing 5]



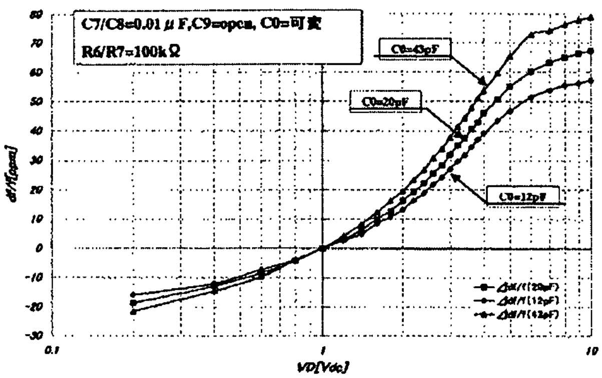
[Drawing 6]



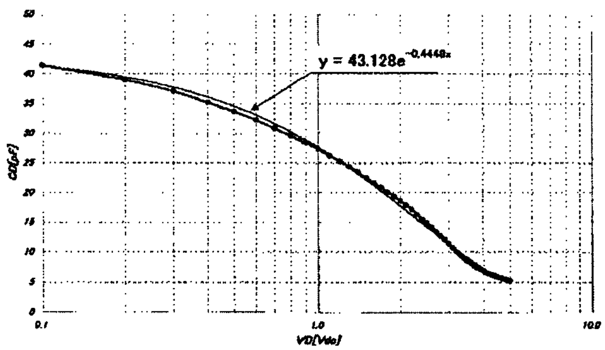
[Drawing 7]



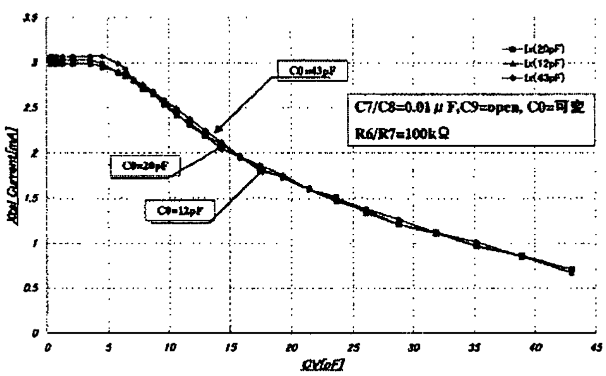
[Drawing 8]



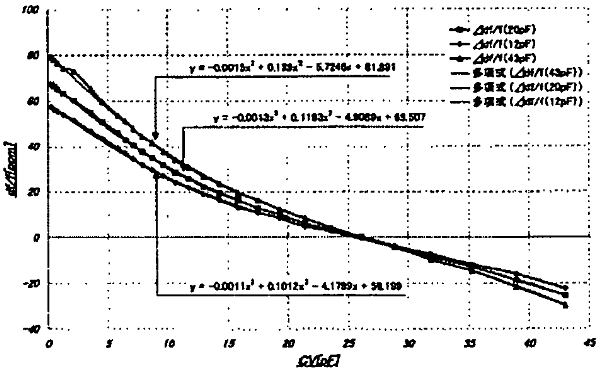
[Drawing 9]



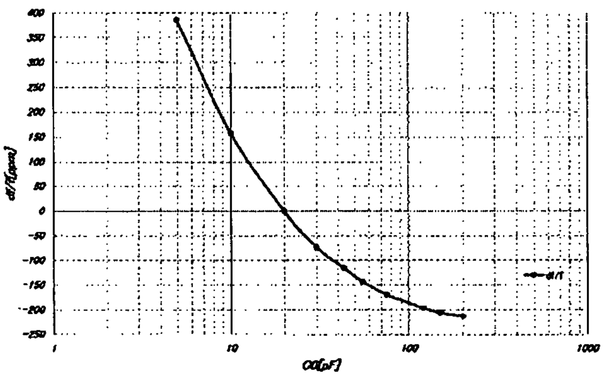
[Drawing 10]



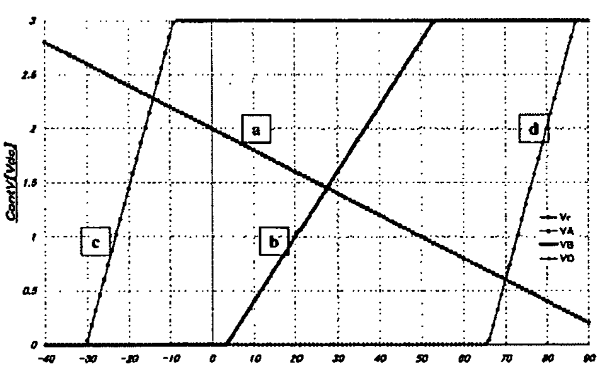
[Drawing 11]



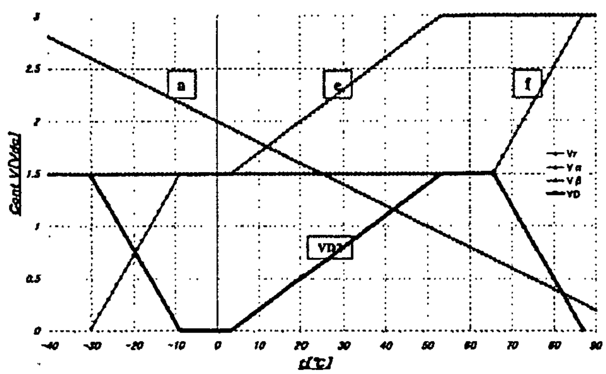
[Drawing 12]



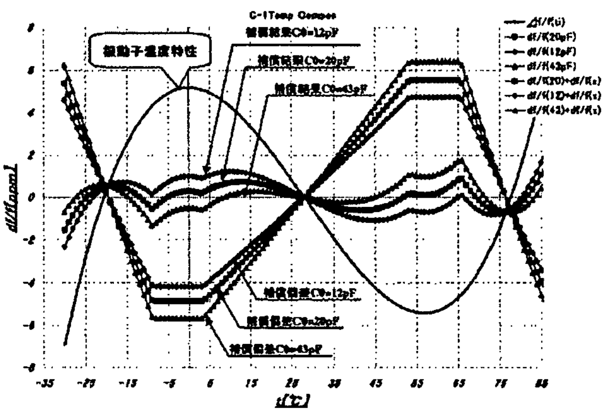
[Drawing 13]



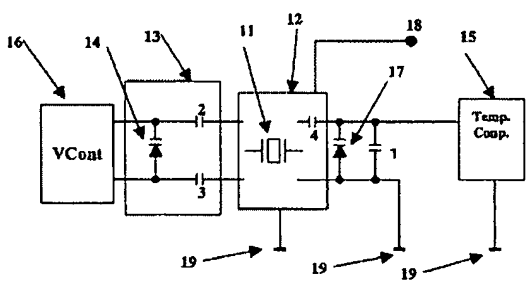
[Drawing 14]



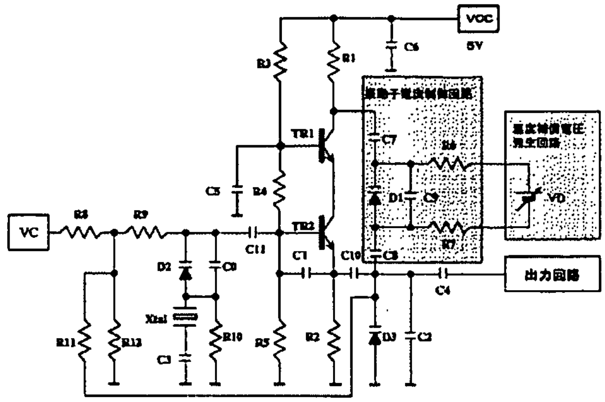
[Drawing 15]



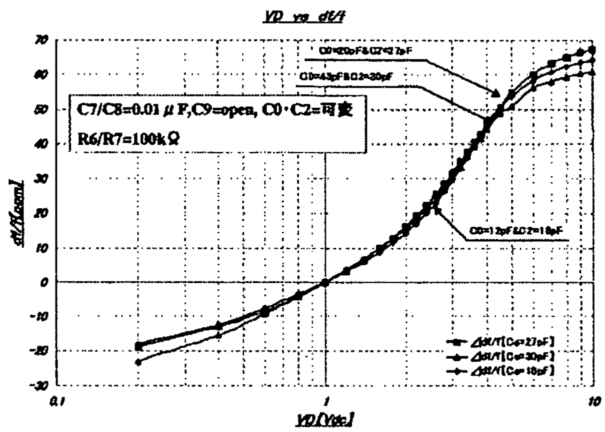
[Drawing 16]



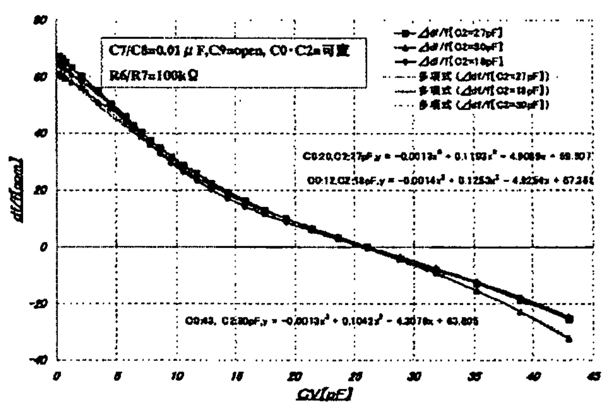
[Drawing 17]



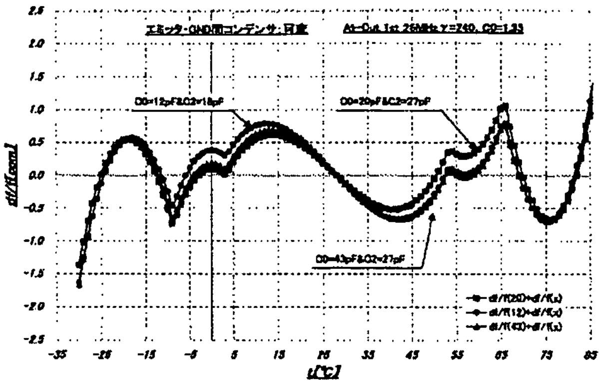
[Drawing 18]



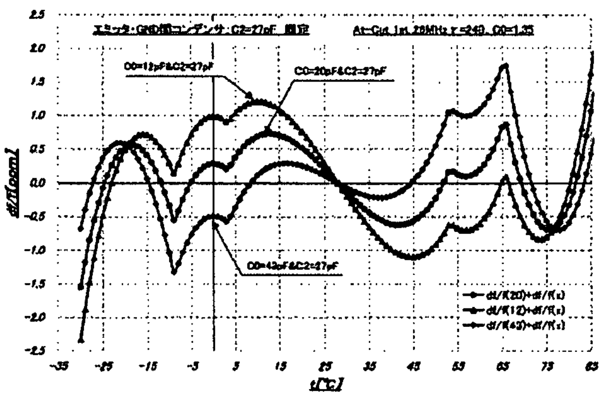
[Drawing 19]



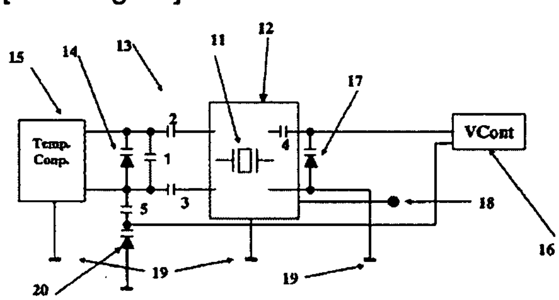
[Drawing 20]



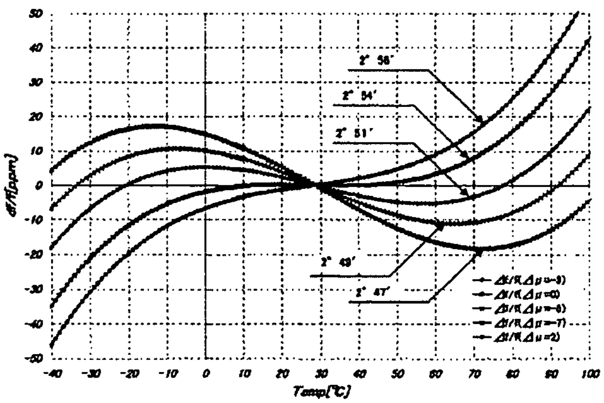
[Drawing 21]



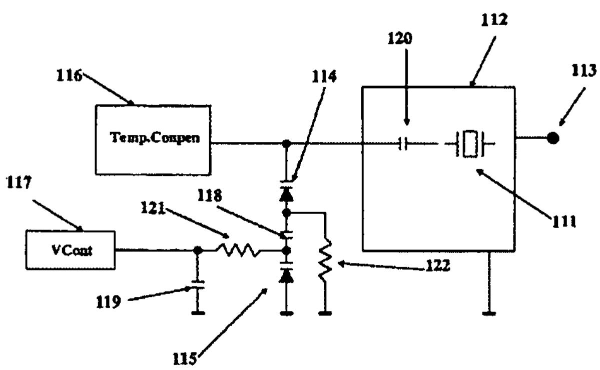
[Drawing 22]



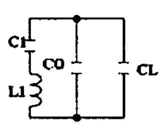
[Drawing 23]



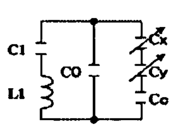
[Drawing 24]



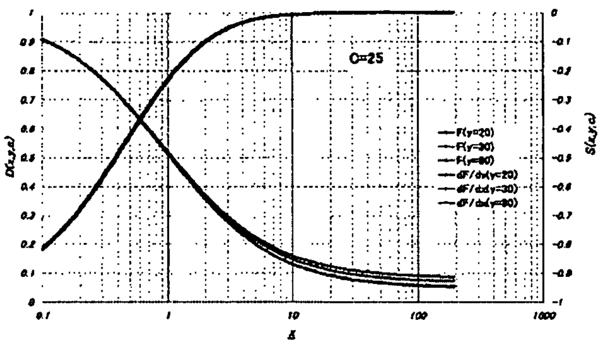
[Drawing 25]



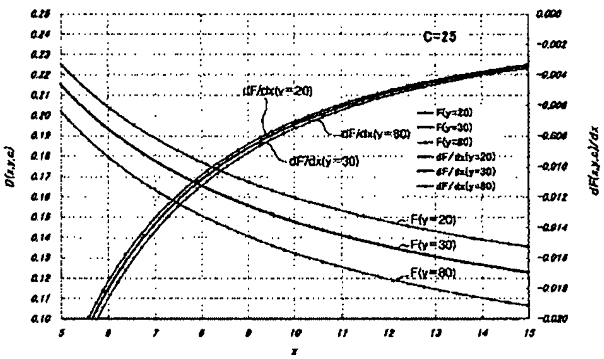
[Drawing 26]



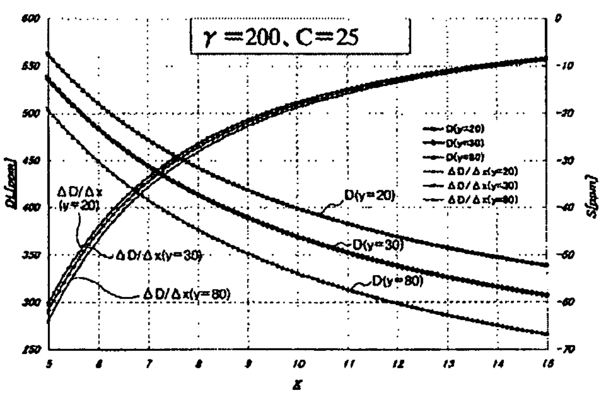
[Drawing 27]



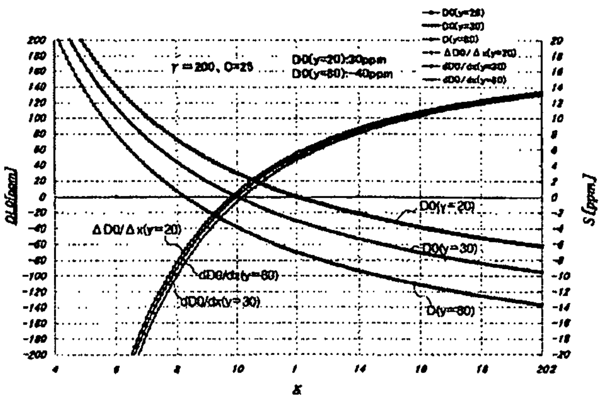
[Drawing 28]



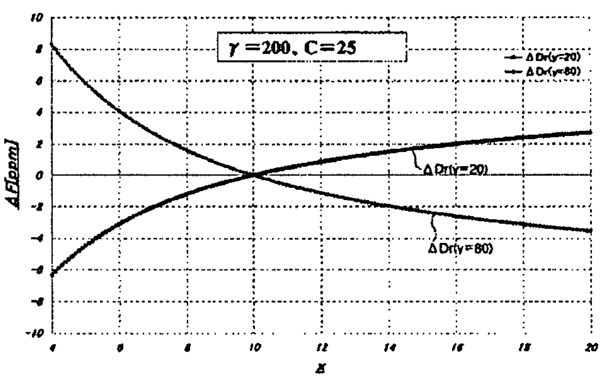
[Drawing 29]



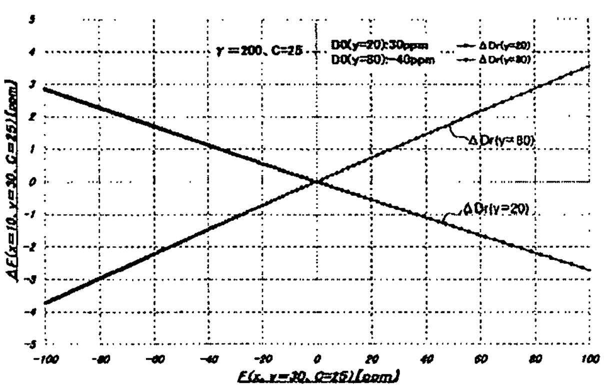
[Drawing 30]



[Drawing 31]



[Drawing 32]



[Translation done.]

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☑ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: ______________________

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.